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Non-alcoholic fatty liver disease among people living with HIV on long-term antiretroviral therapy in Indonesia: Prevalence and related factors

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Abstract

Background/objectives: As people with human immunodeficiency virus experience longer life expectancy, other causes of morbidity and mortality are being increasingly identified. The incidence of non-alcoholic fatty liver disease has recently been on the rise in Indonesia. People with human immunodeficiency virus on antiretroviral therapy are also at an increased risk of having non-alcoholic fatty liver disease. The study aimed to define the prevalence and factors associated with non-alcoholic fatty liver disease in people with human immunodeficiency virus on stable antiretroviral therapy.

Methods: A cross-sectional study of people with human immunodeficiency virus, on antiretroviral therapy, age younger than 18 years old, and without hepatitis co-infection was conducted at the human immunodeficiency virus Integrated Clinic Cipto Mangunkusumo Hospital, Jakarta, Indonesia. Non-alcoholic fatty liver disease was diagnosed using transient elastography with associated controlled attenuation parameter examination (diagnostic cutoff: 238 db/m). A logistic regression test with Poisson regression was used to evaluate factors associated with non-alcoholic fatty liver disease.

Results: One hundred and five people with human immunodeficiency virus were included, with a median age of 39 years and 65.7% were men. The prevalence of non-alcoholic fatty liver disease was 52.4%. Factors related to non-alcoholic fatty liver disease were hypertension (aPR: 1.49, 95% CI: 1.03–2.14, $p = 0.033$) and triglyceride levels (aPR: 1.001, 95% CI: 1.000–1.002, $p = 0.024$). No human immunodeficiency virus-specific variables were associated with non-alcoholic fatty liver disease.

Conclusions: More than half of Indonesian people with human immunodeficiency virus on antiretroviral therapy in this study were found to have non-alcoholic fatty liver disease. Hypertension and increased triglyceride levels were related to non-alcoholic fatty liver disease. Screening for non-alcoholic fatty liver disease should be implemented as a means of early intervention and to prevent complications.

Keywords

Non-alcoholic fatty liver disease, HIV, highly active antiretroviral therapy, hypertension, dyslipidemia

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Introduction

Human immunodeficiency virus (HIV) is a major public health concern, with recent data reporting an estimated 39 million people living with HIV (PLWH) worldwide at the end of 2022. At that time, the incidence of HIV was 1.3 million and 630,000 people died from HIV-associated causes.[1] During these past few decades, the combination of antiretroviral therapy (ART) has significantly increased life expectancy for PLWH in high-income countries. From 2000 to 2003, the overall life expectancy of PLWH compared to non-PLWH at 21 years of age was 37.6 years compared to 59.7 years (22.1 years difference), while from 2014 to 2016, these increased to 56 and 64.1 years (9.1 years difference), respectively. Nonetheless, this has not been followed with trends of comorbidity-free years. Comorbidity-free years of PLWH

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compared to non-PLWH at 21 years of age was 11.3 and 26.6 years (15.3 years difference) from 2000 to 2003, and these numbers persisted from 2014 to 2016, at 14.5 and 30.9 years (16.3 years difference), respectively.[2] In 2020, only an approximate 64% of PLWH knew of their status; 34% of whom were on ART. Of the PLWH on ART, 17% were virally suppressed. With underdiagnosis and being a developing country, Indonesia still has a long way to go, as those numbers are still far from The Joint United Nations Program on HIV/AIDS (UNAIDS) aim of 95-95-95 targets, in which 95% of PLWH know their status, 95% of them are on ART, and 95% of PLWH on ART have suppressed viral loads.[3]

Liver disease is one of the most common causes of non-HIV-related mortality and one of the most common comorbidities among PLWH.[4] Non-Alcoholic Fatty Liver Disease (NAFLD) is defined as evidence of hepatic steatosis determined by biopsy or imaging in the absence of other causes of hepatic steatosis, that is, hereditary, medication, or alcohol causes, and is recognized as a common liver condition in PLWH.[5] In the general population, the incidence of NAFLD has been increasing over time, estimating that the condition is found in 32% of the adult population. The prevalence of NAFLD varies by region. The estimation in European countries, North America, Africa, and Asia was 30.9%, 35.3%, 13.5%, and 30%, respectively. However, the estimation exceeds 40% in South-East Asian countries.[6] The number is thought to be far higher among PLWH as PLWH have increasing life expectancy associated with more effective ART regimens, wider uptake of ART, and increasing rates of obesity in the general population.[7–10] Non-invasive imaging studies have suggested the prevalence among PLWH is 33.9%, while biopsy of the prevalence of Non-Alcoholic Steatohepatitis (NASH) and significant liver fibrosis has been reported as 48.7% and 23.3%, respectively. A recent meta-analysis by reported an overall pooled prevalence of NAFLD among PLWH was 33.95% (95% confidence interval (CI): 29.67%–38.39%) based on imaging studies. The prevalence of NAFLD among PLWH in Asia was 33.26% (95% CI: 30.12%–36.49%). Both traditional risk factors of NAFLD and ART might contribute to this condition. They reported that PLWH with concomitant NAFLD were more likely to be men (odds ratio (OR): 1.89, 95% CI: 1.49–2.41), had a baseline of hypertension (OR: 1.72, 95% CI: 1.30–2.28), diabetes (OR: 2.11, 95% CI: 1.62–2.77), hyperlipidemia (OR: 2.16, 95% CI: 1.67–2.80), or metabolic syndrome (OR: 4.65, 95% CI: 2.17–9.98). On the other hand, undetectable viral load and use of non-nucleoside reverse transcriptase inhibitors, nucleoside reverse transcriptase inhibitors, as well as protease inhibitors were not associated with NAFLD in PLWH.[8]

The gold standard diagnosis for NAFLD is liver biopsy; however, it carries some serious side effects such as bleeding and pain. A recent method called transient elastography (TE) is painless, rapid, and can be easily performed in bedside settings or a clinic. It allows rapid non-invasive estimation of hepatic fibrosis in patients with various chronic liver diseases, such as chronic hepatitis B, chronic hepatitis C, and NAFLD. This device also enables the quantification of hepatic fat and fibrosis in liver with *controlled attenuation parameter* (CAP). Compared to ultrasound, this method has better diagnostic accuracy. A meta-analysis including nine studies consisting of 1047 NAFLD patients reported TE with CAP as being excellent for F3-4 diagnosis (85% sensitivity and 82% specificity) and F4 fibrosis diagnosis (92% sensitivity and 92% specificity), and as having moderate accuracy for F2-4 fibrosis (79% sensitivity and 75% specificity). TE with CAP is also gaining increased recognition and widespread usage, especially in detecting NAFLD in PLWH.[8]

In the European AIDS Clinical Society guidelines, it is recommended to "assess and monitor disease severity in PLWH in case of suspected NAFLD and metabolic risk factors." The guidelines also highlight the absence of optimal cutoff for the use of CAP as screening. The screening for NAFLD in PLWH using magnetic resonance imaging protein density fat fraction (MRI-PDFF) CAP (with a cutoff of 280 db/m) has shown good accuracy (AUC = 0.86, 95% CI: 0.82–0.90) for diagnosing moderate to severe steatosis.[11] In a Canadian study ($n = 541$), they reported 35% liver steatosis using CAP ($\geqslant$248 db/m). Another screening method in Denmark, using computed tomography, reported a prevalence of 8.6% for patients with moderate to severe steatosis.[12]

Screening, diagnosis, and staging of NAFLD are important steps to ensure good long-term care for PLWH. Identifying factors related to NAFLD in PLWH is also pivotal to enable physicians to recommend and take necessary preventive measures. This study aimed to define prevalence and factors associated with NAFLD in PLWH without chronic viral hepatitis, on stable ART, in a tertiary hospital in Indonesia.

Materials and methods

Study design

We conducted a cross-sectional study involving adult PLWH at the HIV Integrated Clinic, Cipto Mangunkusumo Hospital Jakarta, Indonesia. The study was conducted from July to December 2019.

Patient recruitment

The minimum sample was calculated using the proportion estimates formula. According to a previous cohort study, the prevalence of NAFLD was 48%.[13] With a significance level of 1.96 and absolute power of 10%, the minimum sample required, based on the proportion estimate formula, is 95.[14] Inclusion criteria were patients aged younger than 18 years old, viral suppression (HIV RNA $<$ 50 copies/mL), and adherence to the treatment after the last viral load test.

Exclusion criteria were patients who had previously tested positive for hepatitis B and C, consumed excessive amounts of

alcohol—according to NAFLD guidelines from the American Association for the Study of Liver Disease (AASLD)—and faced physical difficulties for TE measurement. The AASLD defines excessive alcohol consumption as more than 21 glasses of alcoholic beverages on average per week for men and 14 glasses for women.[15] Positive hepatitis B is defined by positive hepatitis B antigen results. Positive hepatitis C is defined by positive anti-HCV RNA results. Central obesity was measured with waist circumference according to National Cholesterol Education Program—Adult Treatment Panel – III (NCEP-ATPIII) for the Asian population with a cutoff of 90 cm for men and 80 cm for women.[16]

Measurement and laboratory assays

Age, sex, body mass index (BMI), central obesity, smoking history, alcohol consumption, comorbidities, duration of HIV condition, risk factors for HIV, and type of ART were recorded in a physician-administered questionnaire through history-taking and physical examination. Lipid profile and fasting insulin level were collected after 12-h of fasting.

TE with CAP examination was performed by a single experienced examiner using TE Fibroscan (Echosens). The criteria for successful examination were 10 shots and an interquartile range for liver stiffness less than 20% of the median value. The cut-off value for NAFLD diagnosis was CAP measurement above 238 db/m.[17,18] The presence of liver fibrosis was defined as mild (F1) if liver stiffness measurements (LSM) $\geq$ 7.0–8.1 kPa, moderate fibrosis (F2) if LSM $\geq$ 8.2–9.6 kPa, advanced fibrosis (F3) if LSM $\geq$ 9.7–13.5 kPa, and cirrhosis (F4) if LSM $\geq$ 13.6 kPa.[19]

Statistical analysis

Continuous variables are expressed as median (min–max) and mean (standard deviation, SD). Categorical variables are presented as numbers (percentage). Bivariate analysis of categorical variables was conducted using x^2 or the Fisher's exact test, while the numerical variables were tested using the *T*-test or Mann–Whitney test. All variables with *p*-values < 0.25 in the bivariate analysis were included in the multivariate analysis. Logistic regression test with Poisson regression was used to determine the related factors for NAFLD. Statistical significance was defined as a *p*-value < 0.05. All statistical analyses were done using Statistical Package for Social Science (SPSS) version 14.0 for Windows software (IBM Corp., Armonk, New York, USA).

Ethical aspects

The study design and protocol were approved by the Ethical Committee of the Faculty of Medicine Universitas Indonesia (Ethical Permission No. 0702/UN2.F1/ETIK/2018, published 16 July 2018). All study procedures and data collection were performed after participants provided their written informed consent.

Results

Of the 105 study participants, the majority were men (65.7%) with a median age of 39 (21–69) years old. Most patients were in the 25–49 years old age group, followed by 50 years old and older, and finally those aged 20–24 years old. The most common risk factors, in regard to route of transmission, were heterosexuality, homosexuality, *intravenous drug user* (IVDU), bisexuality, and tattoos. Patients had HIV durations of median 6 (1–15) years and ART durations of median 5 (1–15) years. Most patients consumed NNRTI-based therapy (65.7%). Mean BMI was 24.95 (3.90) kg/m^2, and waist circumference was 83.6 (10.6), with mens having higher (84.7 kg/m^2) measurements than women (81.6 kg/m^2). Central obesity was found in 35.2% of participants. Twenty-nine patients (27.6%) had hypertension, and 3 (2.9%) had diabetes mellitus. Participants had a mean of 209 (44.5) mg/dl total cholesterol, a mean of 127 (38) mg/dl *low density lipoprotein* (LDL), a median of 137 (40–952) mg/dl triglyceride, a median of 82 (41–454) mg/dl fasting glucose, and a median of *Homeostatic Model Assessment of Insulin Resistance* (HOMA IR) of 1.96 (0.37–17.92). The mean liver stiffness value was 5.52 kPa (SD 2.47). Most participants (84.7%) did not have liver fibrosis (F2 or more). Other participant characteristics are summarized in Table 1.

Overall, 55 out of 105 patients had NAFLD, constituting a prevalence of 52.4%. Univariate analysis identified significant associations between NAFLD and BMI (*prevalence ratio* (PR): 1.09, 95% CI: 1.05–1.13, $p < 0.001$), central obesity (PR: 1.91, 95% CI: 1.35–2.70, $p < 0.001$), hypertension (PR: 1.88, 95% CI: 1.36–2.60, $p < 0.001$), fasting blood glucose (PR: 1.002, 95% CI: 1.001–1.004, $p < 0.001$), triglyceride (PR: 1.001, 95% CI: 1.001–1.002), and HOMA-IR (PR: 1.08, 95% CI: 1.03–1.14, $p < 0.003$). None of the HIV-specific variables were related to NAFLD.

Multivariate analysis showed the following HIV non-specific variables as independently associated with NAFLD: hypertension (PR: 1.49, 95% CI: 1.03–2.14, $p = 0.033$) and triglyceride levels (PR: 1.001, 95% CI: 1.000–1.002, $p = 0.024$). Bivariate and multivariate results are summarized in Table 2.

Discussion

This cross-sectional study, based on a well-characterized HIV patients without viral hepatitis coinfection or significant alcohol intake found NAFLD as a major comorbidity in 52.4% of PLWH. The main predictors were hypertension and triglyceride levels. Most studies that have investigated NAFLD in PLWH used non-invasive diagnostic imaging, such as ultrasound, Magnetic Resonance Spectroscopy (MRS), or CT. Ultrasound is less accurate than CAP in diagnosing NAFLD with sensitivities of 28%–67% and 89%–91%, respectively.[20] TE with CAP also has the benefit of providing an estimation of liver fibrosis and steatosis simultaneously. It is operator-independent and is done in a point-of-care manner. Two similar

Table 1. Subject characteristics.

Characteristics	Total ($n = 105$)	n (%)
Age (year)	39 (21–69)	
20–24		2 (1.9)
25–49		85 (81.0)
⩾50		18 (17.1)
Sex		
Male		69 (65.7)
Female		36 (34.3)
Risk factor		
Heterosexual		67 (63.8)
Homosexual		24 (22.9)
Bisexual		2 (1.9)
Tattoos		1 (1)
IVDU		4 (3.8)
Others		7 (6.7)
Duration of HIV (year)	6 (1–15)	
Duration of ART (year)	5 (1–15)	
Category of ART		
NNRTI-based*		69 (65.7)
PI-based**		36 (34.3)
BMI (kg/m^2)	24.95 (3.90)	
Waist circumference (cm)	83.6 (10.6)	
Male	84.7 (10.0)	
Female	81.6 (11.7)	
Central obesity		37 (35.2)
Hypertension		29 (27.6)
Diabetes		3 (2.9)
Total cholesterol (mg/dl)	209 (44.5)	
LDL (mg/dl)	127 (38)	
Triglyceride (mg/dl)	137 (40–952)	
Fasting glucose (mg/dl)	82 (41–454)	
HOMA-IR	1.96 (0.37–17.92)	
Liver stiffness	5.52 (2.47)	
F1		89 (84.7)
F2		8 (7.6)
F3		4 (3.8)
F4		4 (3.8)

IVDU, intravenous drug user; HIV, human immunodeficiency virus; ART, antiretroviral therapy; NNRTI, non-nucleoside reverse transcriptase inhibitor; PI, protease inhibitor; BMI, body mass index; LDL, low-density lipoprotein; HOMA-IR, homeostatic model assessment of insulin resistance; CAP, controlled attenuation parameter; NAFLD, Non-alcoholic fatty liver disease.
*NNRTI-based: NVP, EFV.
**PI-based: LPV/r.

studies have used TE with CAP to determine the prevalence of NAFLD, with prevalences of 42% and 49%, respectively, in PLWH. Here, we report results similar to the cross-sectional studies that have already been published on unselected PLWH.[10,21,22] We used stringent inclusion criteria to ensure that the prevalence of steatosis was truly due to NAFLD. This is also the first study in Indonesia utilizing TE with CAP in HIV patients without viral hepatitis coinfection. Due to the unique characteristics of patients, there were less racial influence (majority Asian people) and epidemiology of metabolic comorbidities.[21–23] This study showed a lower prevalence of IVDU (3.8%) and diabetes (2.9%) compared to previous studies.

Studies assessing steatosis in PLWH with HCV coinfection report wide prevalences of steatosis (11%–72%).[12,24,25] These results might be influenced by measurement bias because liver biopsies have sampling variability limitations and fat deposition is not homogenous throughout the liver.[26]

Sixteen people (15.2%) in the study population were found to have significant liver fibrosis and cirrhosis. This is in line with a cross-sectional study that used TE with CAP in PLWH without viral hepatitis coinfection which showed 17% of the population had significant liver fibrosis.[27] PLWH may acquire liver fibrosis through infection of activated Hepatic Stellate Cells (HSC), which are the main fibrogenic cells in the liver. HIC may promote collagen I expression and secretion of pro-inflammatory chemokines. HIV and gp120 may affect parenchymal and nonparenchymal cells, subsequently causing inflammation and fibrosis. The action of gp120 may cause an increase in HSC migration, subsequently increasing expression of interleukin 6 and secretion of monocyte chemoattractant protein-1, both of which produce a proinflammatory state and cause chronic inflammation.[28]

Hypertension and triglyceride levels were found to be predictors of NAFLD, as also shown in previous studies.[21–23,29,30] A study found an increased risk of NAFLD in PLWH with hypertension (OR: 1.818, 95% CI: 1.117–2.961, $p = 0.016$), although this was insignificant with multivariate analysis (OR: 0.959, 95% CI: 0.510–1.805, $p = 0.897$).[29] Another study reported an increased risk of NAFLD in PLWH with hypertension utilizing multivariate analysis ($p < 0.04$).[21] Similar studies reported an association of dyslipidemia and NAFLD in logistic regression models, with adjusted OR of 2.045, 95% CI: 1.183–3.538, $p = 0.01$ and OR of 1.2, 95% CI: 1.0–1.5, $p = 0.03$, respectively.[29,30] Other studies have found that dyslipidaemia, high triglycerides levels, and higher BMI are associated with higher odds of NAFLD in PLWH, as observed in the general population. It is also well known that cardiovascular risk factors, one of which is hypertension, are highly prevalent in PLWH. These risk factors may result in metabolic syndrome, which is one of the most established risk factors of NAFLD. Since BMI is the most practical method to track obesity as a hallmark of metabolic syndrome, physicians caring for PLWH should encourage patients with obesity to practice healthier lifestyles. High triglyceride levels in PLWH should be managed according to their cardiovascular risk and local recommendations as high untreated triglyceride levels increase the risk of NAFLD. Lipid-lowering agents, such as statins, have been proven to lower NAFLD incidence and slow progression of NAFLD to hepatic fibrosis in cohorts of NAFLD patients.[31–34]

NAFLD prevalence was not found to have a significant relationship with gender in this study. Despite the fact that NAFLD related to metabolic syndrome seems to be

Table 2. Bivariate and multivariate analysis of factors associated with NAFLD.

Variable	NAFLD ($n = 55$)	Non-NAFLD ($n = 50$)	Bivariate analysis		Multivariate analysis	
			PR (95% CI)	*p*	aPR (95% CI)	*p*
BMI (kg/m^2)	24.95 (±3.90)	21.63 (±3.51)	1.09 (1.05–1.13)	<0.001	1.05 (0.99–1.11)	0.058
Male	38 (69.1%)	31 (62%)	1.16 (0.78–1.75)	0.460		
Central obesity	28 (50.9%)	9 (18%)	1.91 (1.35–2.70)	<0.001	1.03 (0.63–1.68)	0.910
Hypertension	23 (41.8%)	6 (12%)	1.88 (1.36–2.60)	<0.001	1.49 (1.03–2.14)	0.033
Fasting blood glucose (mg/dl)	86 (41–454)	79 (51–119)	1.002 (1.001–1.004)	<0.001	0.999 (0.995–1.003)	0.554
Triglyceride (mg/dl)	160 (53–952)	114 (40–383)	1.001 (1.001–1.002)	<0.001	1.001 (1.000–1.002)	0.024
LDL (SD)	131 (±44)	122 (±30)	1.003 (0.999–1.008)	0.180	1.003 (0.999–1.008)	0.167
HOMA-IR	1.96 (0.37–17.92)	1.095 (0.30–7.98)	1.08 (1.03–1.14)	0.003	1.05 (0.95–1.16)	0.341
Nadir CD4	74 (3–374)	73 (3–772)	0.99 (0.998–1.001)	0.372		
Duration of ART						
⩾10 years	12 (21.8%)	7 (14%)	1.58 (0.94–2.64)	0.082	1.345 (0.83–2.19)	0.235
5–<10 years	27 (58.7%)	19 (38%)	1.47 (0.93–2.31)	0.097	1.349 (0.88–2.07)	0.172
<5 years	16 (29.1%)	24 (48%)	Ref	Ref	Ref	Ref

associated with men,[35–37] data on HIV without HCV and HBV patients are inconsistent.[30] A cohort study reported gender-related findings when analyzing the association of HIV with hepatic steatosis. They reported that women with HIV (73% on ART) had a higher liver fat fraction (LFF) than women without HIV, while LFF was similar in men with HIV (97% on ART) and men without HIV. LFF is defined as the ratio of total lipids to unsuppressed water and total lipids, as measured by MRS and expressed as a percentage. Men with HIV had 25% more liver fat than women with HIV, after adjusting for body composition, degree of immunosuppression, viral replication, and ART use. They also reported lower visceral adipose tissue in women than men.[38]

This study found no significant relationship between NAFLD and the duration of ART. Previous studies have presented conflicting results regarding the effect of ART use on NAFLD among PLWH, with most studies showing no association,[29,30,39] while one study showed an association between protease inhibitor use and NRTI (didanosine and stavudine) use with NAFLD.[22] None of our patients received stavudine and didanosine, and only 38.2% were on protease inhibitor. Genetics factors (e.g., host polymerase mutation) may play an important role in determining which patients will progress to steatosis after significant consumption of nucleoside agents.[5] Thus, whether ART plays a first-hand effect in the pathogenesis of NAFLD or a secondary role through metabolic factors such as fat accumulation and/or lipid serum level requires further study.

This study also did not find an association between nadir CD4$^+$ nadir and NAFLD, with similar studies also confirming this finding.[22,29,39] On the other hand, another study observed that CD4 < 200 cells/mm^3 was associated with NAFLD in PLWH after adjustment for other metabolic factors. Of 26 patients with low CD4 counts, 73% of them had detectable viral loads even though most of them were on ART. This study was conducted in a 94% Chinese population and so, their results may not be generalizable to the general population. Another case-control conducted also in a 94% Chinese population reported that neither nadir nor current CD4 was associated with NAFLD. It is postulated that poorer HIV control may often lead to hepatic inflammation that could potentially confound the assessment of fibrosis; therefore, CD4 count screening may be important in the screening of PLWH with suspected NAFLD.[40] Thus, even though there is a postulation of association between the degree of immunosuppression in HIV and NAFLD, it is still not a well-established risk factor for NAFLD.[30]

Previous studies have discussed whether or not universal screening is needed as opposed to screening in a specific population. In the latest European guidelines, it is recommended to screen NAFLD in high-risk populations such as those with familial history, viral hepatitis, medications, and alcohol consumption. Specifically, patients should be stratified using Fibrosis-4 (FIB-4) and/or Enhanced Liver Fibrosis (ELF) in primary care, followed by TE in the specialist office. The guidelines from AASLD suggest yearly testing for FIB-4 for diabetics and people with at least two components of metabolic syndrome and are against universal screening of NAFLD. This is in accordance with PLWH, as studies reporting NAFLD in PLWH usually recruited HIV-monoinfected patients who are non-excessive drinkers with metabolic syndrome, elevated liver enzymes, and/or clinical dystrophy. We recommended that a similar strategy is used to specifically screen PLWH with NAFLD, instead of utilizing universal screening.[41]

Strengths and limitations

The strengths of this study include the stringent eligibility criteria which tried to exclude any other cause of liver disease (viral hepatitis, significant alcohol intake). Additionally, this is the first study utilizing TE CAP to detect NAFLD in

HIV patients without coinfection of viral hepatitis in Indonesia.

There are several limitations in our study. Our small sample size may cause limited generalizability and lack of reliability in our results. Due to its cross-sectional design, our study could not assess a causal relationship. Self-declared alcohol consumption may have been inaccurate, which may lead to imperfect inclusion or exclusion of the study population. We also had a lack of sample size due to limitations of recruitment in research groups. Finally, there was no recent viral replication data, which can serve as data to confirm the involvement of HIV in the pathogenesis of NAFLD.

Future directions

Future studies should investigate the prevalence and factors associated with NAFLD in PLWH in multi-centers. Researchers may also explore the prevalence of MAFLD as data given that these conditions are scarce, especially in Asian populations. Our study, although done in a tertiary hospital center with multiple referrals from other hospitals in Indonesia, should be able to serve as a basis for future collaboration with other HIV center in Indonesia, both to increase the number of patients to be analyzed and broaden the patients' heterogeneity. Such a collaboration could also emphasize the importance of early screening and diagnosis of NAFLD in PLWH for other physicians in other hospitals in Indonesia, especially those in rural areas with limited access.

Conclusions

In conclusion, NAFLD was found to be common in PLWH, occurring in half of the population. High triglyceride levels and hypertension were found to be associated with NAFLD. These findings are important for clinicians and patients as early recognition and prompt treatment methods can prevent further progression and morbidity of NAFLD among the HIV population.

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Authors' contributions

Conceptualization: HP, EY, and RAG. Methodology: HP, EY, RAG, and IR. Data collection and analysis: HP, EY, and IR. Writing—original draft preparation: HP and EY. Writing—review and editing: EY, IH, SM, and RAG. Visualization: HP. Supervision: EY and RAG. All authors have read and agreed to the published version of the manuscript.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declaration of conflicting interests

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Ethics approval

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Informed consent

Written informed consent was obtained from all subjects before the study.

Consent for publication

Not applicable.

Trial registration

Not applicable.

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Supplemental material

Supplemental material for this article is available online.

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