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Chronic alcohol use affects the immune blood cell counts in HIV/ AIDS patients on d4T/3TC/NVP drug regimen during the 9 months follow up period

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ABSTRACT

Chronic alcohol use is a common problem globally including among HIV/ AIDS patients on ARV treatment. Ethanol and its metabolites reduce hemopoiesis and also activate HPA axis releasing cortisols that affect immune blood cell production. Study determined effect of chronic ethanol use on immune blood cell count in HIV/AIDS patients on d4T/3TC/NVP treatment for a period of 9 month follow up. A case control study using repeated measures with serial measurements model was used. Alcohol-Use biomarkers were used to standardize gender differences in alcohol use. A total of 41 patients were screened for chronic alcohol use by the WHO AUDIT tool. The 21 patients were enrolled in the control group that were not chronic alcohol users and the other 20 patients in the chronic alcohol use according to the WHO AUDIT tool scores. Since the tool was not sensitive enough the patients in the control group were again sorted out using the chronic alcohol use biomarkers. Two studies with WHO AUDIT tool group and chronic alcohol use biomarkers were done. Both groups were followed up for 9 months with blood sampling done at 3 month intervals. The immune blood cells (WBC count and differential counts) were determined using automated hematological Coulter CBC-5 Hematology Analyzer. Results were then sorted by alcohol-use biomarkers since WHO AUDIT tool was not sensitive enough to screen patients. Mean WBC counts were slightly higher at baseline and 3 month in chronic alcohol use group as compared to controls. There was variation in differential counts at different time intervals between control and chronic alcohol use for both alcohol-use biomarkers and WHO AUDIT tool groups. Generally, differential counts slightly varied between chronic alcohol use and the control groups but it was statistically insignificant ($p \geq 0.05$) between the 2 groups. Chronic alcohol use by HIV/AIDS patients on d4T/ 3TC/NVP regimen reduced the mean WBC count, % lymphocytes, % monocytes and % basophils in both WHO AUDIT tool and alcohol-use biomarkers group.

KEYWORDS

Chronic alcohol use;
Immune blood cells;
HIV/AIDS patients;
ARVs.

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INTRODUCTION

Chronic alcohol use is a common problem globally including among HIV/AIDS patients on ARV treatment regimens. Alcohol in form of ethanol is by far the most abused drug for centuries world over[1-3]. The types of alcohol consumed in alcoholic beverages include wine, spirits, liquors, beers and traditional local brew[1,2]. The World Health Organization (WHO) estimates that about 2 billion people worldwide consume all forms of alcoholic beverages[4-7]. Alcohol consumption is reported as third largest risk factor for burden of the diseases in developed countries[6,8,9]. In Uganda, alcohol consumption is a serious problem and the country is ranked top in alcohol use among 189 WHO member countries and first in African region[10-13]. The use of alcohol in Uganda is a widely accepted in social and ceremonial activities[6,7,12-15]. In the body, especially in the liver and gastrointestinal tract (GIT), ethanol is broken down by metabolizing enzyme systems such as alcohol dehydrogenases, aldehyde dehydrogenases, cytochrome P4502E1 (CYP2E1) and catalases to generate potentially harmful byproducts such as acetaldehyde, acetate, reactive oxygen species (ROS) such as hydroxyl radicals, superoxide anion and hydroxyl radicals and fatty acid ethyl esters (FAEEs). These cause deleterious effects to various body tissues and organs like the bone marrow, lymphoid organs, liver and immune system[16-19]. They affect hemopoiesis and thus reduces the immune blood cell count (WBC and differential count like basophils, eosinophils and neutrophils – granulocytes, lymphocytes and monocytes - agranulocytes)[20-23]. Acetaldehyde activates the hypothalamic-pituitary-adrenal (HPA) axis similar to acute stress resulting in increased production of cortisols[16,24-26]. Acute stress and acetaldehyde causes release of corticotrophin-releasing factor (CRF) and arginine vasopressin (AVP) by parvocellular cells of paraventricular nucleus (PVN) and supra optic nuclei. The CRF and AVP act synergistically on anterior pituitary gland to release adrenocorticotrophic hormone (ACTH) which then increases the synthesis and release of the glucocorticoids from adrenal gland[16]. Glucocorticoids suppress the cell-mediated immune responses by inhibiting coding genes for the cytokines IL-1, IL-2, IL-3, IL-4, IL-5, IL-6, IL-8 and IFN-γ, the most important being IL-2. They reduce T cell proliferation[16]. Acute and chronic alcohol exposure suppresses all branches of the immune system responses including cells of immune system[27-30]. Cytokines can affect same cell that produced them, a neighboring cell, or distant cells by stimulating or suppressing cell proliferation, production of other cytokines, killing of damaged cells or tumor cells (cytotoxicity), and cell migration (chemotaxis)[27-30]. Antiretroviral drugs also can interact with ethanol and its metabolites to further exaggerate suppression of immune blood cell proliferation in bone marrow and lymphoid organs. The study therefore determined the effect of chronic alcohol use on immune blood cell counts in HIV/AIDS patients on d4T/3TC/NVP regimen using WHO AUDIT tool and chronic alcohol-use biomarkers application.

MATERIALS AND METHODS

Study design

The study was a case-control study that used repeated measures design model and it was conducted at St. Raphael of St. Francis Hospital, Nsambya, ART Private Clinic on the HIV/AIDS patients who were exposed to chronic alcohol and at the same time, they were initiated on the d4T/3TC/NVP drug regimen *[triomune 30 (lamivudine (3TC) 150 mg, nevirapine (NVP) 200 mg and stavudine (d4T) 30 mg tablets)]* for the last 6 months. The hospital handles about 1,500 HIV/AIDS patients. The d4T/3TC/NVP drug regimen was one of the drug regimen used in the suppression of the HIV virus in the patients during the study period. The serial measurements model was done on the HIV/AIDS on d4T/3TC/NVP drug regimen at 3 month intervals (0, 3, 6 and 9 months) for a period of 9 month for both the control group and the chronic alcohol exposed group. Both the control and chronic alcohol use groups were screened for alcohol use by using the WHO AUDIT tool method and the chronic alcohol-use biomarkers elevation (GGT values above 55.0 UI, MCV values above 96 fL and AST/ALT ratio above 2.0). About 1mL of whole blood was collected from the cubital vein for all the patients for the analysis of the biomarkers using the automated hematological Coulter CBC-5 Hematology Analyzer equipment for MCV and the Cobas Intergra 400 Plus analyzer equipment for GGT, AST and ALT serum enzymes analysis.

Study site and population

The study was conducted at St. Raphael of St

Francis hospital, Nsambya, Private clinic and department of Pharmacology and Therapeutics pharmacokinetic laboratory. A total of 41 HIV/AIDS patients who are on d4T/3TC/NVP drug regimen were recruited. They were grouped into two arms with the first arm or the control group consisting of 21 HIV/AIDS patients who were self-reported for not being exposed to any type of alcohol or to chronic alcohol for the past one year. The second arm had 20 HIV/AIDS patients who were self-reported to be exposed to chronic alcohol.

Inclusion criteria

All the HIV/AIDS patients who were included in this study were HIV positive, on d4T/3TC/NVP drug combination regimen for the last 6 months at the time of enrollment. The adherence rates of all the patients recruited were measured using the self-reporting adherence and the pill counts at scheduled visits and all had an adherence rate of above 95%. This was to ensure that the patients were taking their drugs as per the prescription. Also those included were in the age range of 18 to 50 years old. In the test group, they must be exposed to chronic alcohol use at the time of recruitment and during the 9 months study period and in the control group, they were not exposed to any type of alcohol at all or for the last 6 to 12 months.

Eligibility criteria and enrolment of study participants

The study was conducted on the HIV/AIDS patients who were initiated on the d4T/3TC/NVP drug regimen for the last 6 months. At the time of enrollment, a total of 41 HIV/AIDS patients on d4T/3TC/NVP were screened for chronic alcohol use using the WHO Alcohol Use Disorder Identification Test (AUDIT) tool. The 20 patients (13 males and 7 females) were identified to consume alcohol chronically using the tool and were enrolled into the chronic alcohol use group after signing the consent forms. The 21 patients (17 males and 4 females) were identified by the tool as non-alcohol consumers by the tool and were enrolled in the control group still after consent. The WHO AUDIT is currently an important tool which is non-invasive and it's routinely used worldwide to screen patients on chronic alcohol consumption[31]. The AUDIT tool has a set of 10 questions, each with responses and scores which the individual responds by self-reporting. A total score of 8-15 indicates hazardous alcohol use, 16-19 indicates alcohol use problem and scores above 20 indicates alcohol use dependence[31]. All the patients recruited in the chronic alcohol group had a total score of above 8 according to the WHO AUDIT tool interpretation of the scores. The patients enrolled in the control group had a score value of less that 8 according to the WHO AUDIT tool interpretation of the scores. However because the WHO AUDIT was not sensitive enough to actually detect some of the patients in the control group who were consuming alcohol chronically, the chronic alcohol-use biomarkers (GGT, MCV and AST/ALT ratio) were used to further sort out the patients in the control group who were being exposed to chronic alcohol and could not be detected by the WHO AUDIT tool. Therefore the 41 HIV/AIDS patients were again grouped according to the chronic alcohol use biomarkers into 2 arms with the chronic alcohol use arm having 26 patients (22 males and 4 females) and the control group with 15 patients (8 males and 7 females). These HIV/AIDS patients in both the control and chronic alcohol exposed group were followed-up for 9 months starting from March 2008 to November 2008. Each HIV/AIDS patient was explained well about the study and any questions raised were answered. All those patients who participate in the study signed the consent forms. The baseline serum enzyme concentrations (GGT, ALT and AST) at time 0 month just before they were initiated on the d4T/3TC/NVP drug regimen of all the patients that participated in the study were collected retrospectively from the patients records.

Whole blood sample collection and processing

Whole blood samples from recruited HIV/AIDS patients on d4T/3TC/NVP regimen were collected from cubital vein every 3 months for a period of 9 months. About 2 ml of whole blood were collected from each patient's visit into EDTA-containing vacutainer for immune blood cell count determination.

Immune blood cell count determination

Study was carried out at Mulago National Referral Hospital Clinical chemistry and Hematology laboratory using automated hematological Coulter CBC-5 Hematology Analyzer equipment using standard procedures and laboratory standard operating procedures (SOPs). The total WBC count and differential count were determined for all the blood samples.

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Data analysis

The data was analyzed by SAS 2003 version 9.1 statistical package for statistical data analysis at 95% confidence interval. The repeated measures fixed model was used in the statistical data analysis. The t-test was used to compare the means for HIV/AIDS patients who were in the chronic alcohol use (chronic alcohol use group) and the control group at different time intervals.

Ethical consideration

Study was approved by Makerere University Institution Review Board (IRB) (IRB#-2007-060), IRB of St. Raphael of St Francis hospital, Nsambya (no. IRB 03: 01/03/2008) where study participants were recruited from and Uganda National Council for Science and Technology (UNCST) (no. HS 387). In this study, a written informed consent was obtained from each human subject and that all procedures used were in accordance with ethical standards of responsible committee on human experimentation (institutional or regional) and with Helsinki Declaration of 1975, as revised in 1983. They were given study code numbers which were used all through study period in order to protect their privacy and confidentiality.

RESULTS

Data shows that mean WBC count for both chronic alcohol use and control group were within reference ranges of 4.0 – 11.0 x10^3µl in both WHO AUDIT tool and biomarkers group (TABLE 1 and 2). However, mean WBC count in chronic alcohol use in 0, 6 and 9 month were lower than control group for WHO AUDIT tool except in 3 month but difference was statistically insignificant ($p \geq 0.05$) (TABLE 1). For biomarkers group, mean WBC count in chronic alcohol use group were higher in 0 and 3 month while lower in 6 and 9 month but statistically insignificant ($p \geq 0.05$) (TABLE 2). Overall mean WBC count in chronic alcohol use group was lower than in control group but statistically insignificant ($p \geq 0.05$) for both WHO AUDIT tool and biomarkers groups (TABLE 3 and Figure 1).

Mean % neutrophil in WHO AUDIT tool and biomarkers groups were lower than reference ranges. Mean % NE in chronic alcohol use group were slightly lower than control group in 0, 3 and 6 month but statis-

TABLE 1 : Variation of immune cells and differential counts with time among the control and chronic alcohol-use group using alcohol-use self-reporting

Mean Immune blood cells		Time of follow-up (months)				Ref. values
		0	3	6	9	
WBC±SE x10^3µl	Control	5.65±1.85	5.06±1.51	5.66±2.29	5.47±1.74	4.0-11.0
	Alcohol	5.61±1.62	5.37±1.45	5.46±2.41	4.77±1.04	
p-value		0.80	0.62	0.76	0.16	
NE ±SE(%)	Control	38.50±12.76	39.83±13.15	40.01±10.53	38.48±11.68	45-70
	Alcohol	41.50±12.28	40.32±13.38	40.63±10.9	38.43±7.3	
p-value		0.18	0.99	0.98	0.98	
LY ±SE(%)	Control	42.43±8.03	43.41±10.19	43.07±8.75	45.85±9.61	20-40
	Alcohol	40.20±12.99	45.04±14.20	45.44±9.86	46.30±0.99	
p-value		0.35	0.50	0.21	0.86	
MO ±SE(%)	Control	10.42±3.93	8.16±2.52	9.39±2.76	8.41±2.77	3-10
	Alcohol	8.79±3.66	7.23±1.96	8.63±2.36	8.35±2.63	
p-value		0.24	0.26	0.36	0.95	
EO ±SE(%)	Control	7.90±7.86	7.88±7.27	6.97±7.36	6.65±6.6	1-5
	Alcohol	8.83±11.59	6.75±8.25	4.53±5.29	6.36±6.39	
p-value		0.87	0.63	0.28	0.90	
BA ±SE(%)	Control	0.79±0.53	0.73±0.47	0.56±0.22	1.21±1.79	0-0.5
	Alcohol	0.67±0.32	0.65±0.25	0.78±0.67	0.56±0.21	
p-value		0.29	0.52	0.14	0.16	

Key: Ref: Reference values; SE: standard error; WBC: white blood cells; NE: neutrophils; LY: lymphocytes; MO: monocytes; EO: eosinophils; BA: basophils

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TABLE 2 : Variation of mean immune cells and mean differential counts with time among the control and chronic alcohol-use group using alcohol-use biomarkers

Mean immune blood cells		Time of follow-up (months)				Ref values
		0	3	6	9	
WBC x10^{3}µl	Control	5.57±1.91	4.98±1.46	5.79±2.45	5.68±1.97	4.0-11.0
	Alcohol	5.68±1.61	5.35±1.5	5.44±2.29	4.84±1.06	
p-value		0.89	0.53	0.73	0.15	
NE ±SE(%)	Control	38.96±13.43	41.2±13.67	39.5±8.85	41.07±11.01	45-70
	Alcohol	40.74±11.90	39.34±12.95	40.74±11.5	37.15±8.77	
p-value		0.74	0.62	0.66	0.41	
LY ±SE(%)	Control	41.96±7.16	41.91±9.87	44.10±7.01	43.06±8.52	20-40
	Alcohol	40.85±12.91	45.67±13.44	44.38±10.37	47.58±8.14	
p-value		0.63	0.29	0.93	0.23	
MO ±SE(%)	Control	9.97±3.87	7.61±2.07	9.36±2.94	7.76±2.61	3-10
	Alcohol	9.35±3.88	7.76±2.45	8.82±2.38	8.69±2.69	
p-value		0.34	0.56	0.55	0.64	
EO ±SE(%)	Control	8.46±8.37	8.57±8.06	6.49±5.84	7.48±7.9	1-5
	Alcohol	8.26±10.89	6.53±7.67	5.33±6.77	6.02±5.64	
p-value		0.73	0.56	0.61	0.94	
BA ±SE(%)	Control	0.68±0.44	0.71±0.47	0.55±0.19	1.01±1.28	0-0.5
	Alcohol	0.77±0.45	0.68±0.25	0.73±0.6	0.82±1.33	
p-value		0.97	0.43	0.12	0.26	

Key: Ref: Reference values; SE: standard error; WBC: white blood cells; NE: neutrophils; LY: lymphocytes; MO: monocytes; EO: eosinophils; BA: basophils

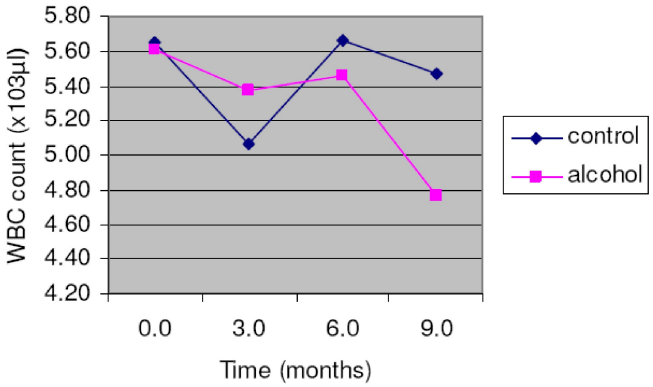

Figure 1 : Variation of the mean WBC count in HIV/AIDS patients on d4T/3TC/NVP with time among the control and the chronic alcohol-use group in the alcohol-use self reporting group

tically insignificant (p≥0.05) in WHO AUDIT tool group (TABLE 1). In biomarkers group, mean % NE in chronic alcohol use group were lower in 3 and 9 month but still statistically insignificant (p≥0.05) (TABLE 2). Overall mean % NE in chronic alcohol-use for WHO AUDIT tool was higher in chronic alcohol use group and reverse was true for biomarkers group and in both, they were statistically insignificant (p≥0.05) (TABLE 3 and Figure 1).

Mean % lymphocytes (LYP) in both chronic alcohol use and control groups were higher than reference ranges in both WHO AUDIT tool and biomarkers groups (TABLE 1 and 2). Mean % LYP in chronic alcohol use group was generally higher than control group but difference was statistically insignificant (p≥0.05) and same was true for overall mean % LYP (TABLE 1, 2 and 3 and Figure 1).

Mean % monocytes (MO) in both WHO AUDIT tool and biomarkers groups were within normal reference ranges of 3 – 10% (TABLE 1 and 2). Mean % MO in chronic alcohol use group were lower than in control group for WHO AUDIT tool group while in biomarkers group, mean % MO in chronic alcohol use group were higher in 3 and 9 month but difference in both groups were statistically insignificant (p≥0.05) (TABLE 1 and 2). Overall mean % monocytes in chronic alcohol use group were lower than in control group for both WHO AUDIT tool and biomarkers groups and difference was statistically insignificant (p≥0.05) (TABLE 3 and Figure 1).

Mean % eosinophils (EO) in chronic alcohol use and control group for both WHO AUDIT tool and

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TABLE 3 : The overall effect of chronic alcohol consumption by the HIV/AIDS patients on d4T/3TC/NVP treatment regimen on the immune cells in chronic alcohol-use self reporting WHO AUDIT tool and the chronic alcohol-use biomarkers groups during the 9 month follow-up period

Chronic alcohol-use self reporting WHO AUDIT tool group			
Mean immune blood cells	**Control group**	**Chronic alcohol consumption**	**p value**
WBC ±SE $x10^3\mu l$	5.27±0.35	4.83±0.33	0.358
NE ±SE (%)	36.82±2.26	39.12±2.12	0.464
LY ±SE (%)	48.09±2.04	46±0.04	0.470
MO ±SE (%)	8.5±0.67	8.04±0.63	0.623
EO ±SE (%)	5.99±1.54	6.24±1.44	0.907
BA ±SE (%)	1.33±0.34	0.56±0.32	0.105
Chronic alcohol-use biomarkers groups			
WBC ±SE $x10^3\mu l$	4.863±0.40	4.86±0.25	0.987
NE ±SE (%)	39.76±3.31	38.81±2.09	0.809
LY ±SE (%)	43.30±2.89	46.44±1.83	0.368
MO ±SE (%)	9.09±1.02	8.31±0.64	0.524
EO ±SE (%)	5.31±2.04	5.90±1.29	0.809
BA ±SE (%)	0.66±0.43	0.87±0.27	0.693

biomarkers groups were higher than reference ranges of 1 – 5% except in 6 month for WHO AUDIT tool group (TABLE 1 and 2). Mean % EO in chronic alcohol use group was generally lower than control group but difference was statistically insignificant ($p \geq 0.05$). Overall mean % EO in chronic alcohol use group were slightly higher than in control group for both WHO AUDIT tool and biomarkers groups but difference was statistically insignificant ($p \geq 0.05$) (TABLE 3 and Figure 1).

Mean % basophils (BA) in chronic alcohol use group and control group for both WHO AUDIT tool and biomarkers groups were higher than reference ranges of 0 – 0.5% (TABLE 1 and 2). In WHO AUDIT tool group, mean % BA in control group were higher than in chronic alcohol use group except in 6 month but was statistically insignificant ($p \geq 0.05$) (TABLE 1). In biomarkers group, mean % BA in chronic alcohol use group were higher than in control group in 0 and 6 month but difference was statistically insignificant ($p \geq 0.05$) (TABLE 2). Overall mean % BA in WHO AUDIT tool group for chronic alcohol use group was lower than in control group and reverse was true for biomarkers groups (TABLE 3 and Figure 1).

DISCUSSION

The observed low values of the mean WBC count in HIV/AIDS patients on d4T/3TC/NVP drug regimen could have been due to the interaction of ethanol and its metabolites with the antiretroviral drugs that tends to suppress the bone marrow and lymphoid organs that are involved in production of these cells as well as the HIV viral infection its self[32-35]. Also alcohol metabolite, acetaldehyde, acetate, reactive oxygen species (ROS) such as hydroxyl radicals, superoxide anion and hydroxyl radicals and fatty acid ethyl esters (FAEEs) activate the HPA axis to release CRF and AVP that act synergistically on anterior pituitary gland to release ACTH and glucocorticoids that suppress the cell-mediated immunity by reducing the T cell proliferation[16]. The increased mean WBC count values observed in some of the HIV/AIDS patients on the d4T/3TC/NVP drug regimen could have been due to response by the body to the HIV viral and other opportunistic infections, an allergic or toxic reaction associated with the ARVs and other chemicals like the herbs which the patients may be taking[16,34,36]. The observed increase in the % neutrophil in the HIV/AIDS patients on the d4T/3TC/NVP drug regimen could have been due to bacterial infections like opportunistic *Mycobacteria tuberculosis* infections since these patients are immunocompromised, stress due to HIV/AIDS disease and the drugs like ARVs[16,34,36]. However the overall observed reduction in the % neutrophil in the patients below the normal % neutrophil normal laboratory reference range values of 45-70% could have been due to the HIV viral infections which are continuously destroying the immune system as well as other idiopathic diseases[16,34,36]. It could also be due to the effect of alcohol and its metabolites on the bone marrow and the lymphoid organs[16,34,36]. The observed increased mean % lymphocytes could have been due to the stimulation of the bone marrow and the lymphoid organs to produce the lymphocytes in response to the HIV infection that targets the $CD4^+$ cells which are part of the lymphocytes to which they destroy and therefore weakening the body immune system and as a way to fight back they lymphoid tissues increases the production of the different types of the lymphocytes[16,34,36,37]. It could also be due to the effect of the acetaldehyde metabolite on HPA axis leading to the production of the glucocorti-

coids thus suppressing the proliferation of these cells of the immune system[16]. The lymphocytes can also increase in various acute viral infections like HIV infection in these patients or bacterial infections and immunological responses as well as acute stress due to HIV[16,34,36,37]. The slightly higher values for the control group could have been due to the HIV viral infections and inflammatory reactions associated with the disease. These cells also increase in chronic infections like the HIV infection or inflammations and are involved in the capture and destroying of opportunistic infections like bacteria and other foreign substances that may be associated with the HIV/AIDS disease[32-34,38,39]. Therefore the monocytes can be used to monitor the HIV/AIDS disease progression. The observed low % monocytes especially in the chronic alcohol consumption group could be due to the effect of alcohol and its acetaldehyde metabolites on bone marrow and the lymphoid tissues[32-34,38,39]. The observed increase in the % eosinophils could be due to opportunistic infections that may immune-compromise individual patients. Also EOS also reported to fluctuate greatly during day and night, seasonally and with phases of menstrual cycle in females[27,32-34,38,39]. The reduction in % eosinophils could have been due to HIV or ARV chemotherapy effect on bone marrow and the lymphoid tissues. Acetaldehyde, acetate, reactive oxygen species (ROS) such as hydroxyl radicals, superoxide anion and hydroxyl radicals and fatty acid ethyl esters (FAEEs) metabolite activates HPA axis leading to production of glucocorticoids that suppress proliferation immune system cells[16]. Increase in mean % basophils could be due to HIV/AIDS disease complex in which body tries to respond to HIV viral infection[19,27,32,33]. These cells are used to monitor HIV/AIDS disease progression HIV/AIDS patients[19,27,32,33]. Low % basophil could be due to effect of alcohol and its metabolites on immune system[16]. However, since the study was an effective type of study where all the patients were observed in their natural settings, the confounders in the study that may have affected the immune blood cells in both the control and chronic alcohol use groups were assumed to be the same. Therefore the variable chronic alcohol use could have caused the observed increment in the immune blood cell counts in chronic alcohol use group for both the WHO AUDIT tool and chronic alcohol-use biomarkers groups in the study. Chronic alcohol use by the HIV/AIDS patients on the d4T/3TC/NVP drug regimen affects the immune blood cell counts during the 9 month period of follow up.

CONCLUSION

Alcohol and its metabolites leads to the production of reactive oxygen species (ROS), the fatty acid ethyl esters (FAEEs) and acetaldehyde metabolites that destroy bone marrow and lymphoid organs involved in immune blood cell production. Ethanol and acetaldehyde stimulates HPA leading to increased glucocorticoid production that suppresses immune blood cells function in HIV/AIDS patients observed in the study. ARVs also interact with ethanol and its metabolites acetaldehyde to increase the suppression of the immune cell production. Chronic ethanol use generally reduces the immune blood cells count in the HIV/AIDS patients on d4T/3TC/NVP treatment regimen.

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