Journal of Cardiovascular Disease Research

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 06, 2023

Original research article

To assess the reliability of total lymphocyte count as a substitute for CD4 count to monitor the response to HAART in HIV patient

[1]Dr. Bharath Singh Vadthiyawath, [2]Dr. Devaragatla Ravikiran, [3]Dr. Ketavath Sravya Sree, [4]Dr. Rajesh Vanam

[1, 3]Assistant Professor, Department of General Medicine, Government Medical College, Nalgonda, Telangana, India

[2]Assistant Professor, Department of Pulmonary Medicine, Government Medical College, Nalgonda, Telangana, India

[4]Assistant Professor, Department of General Medicine, MGM Hospital, Kakatiya Medical College, Warangal, Telangana, India

Corresponding Author:
Dr. Rajesh Vanam

Abstract

Aim and Objectives
To study the relationship between CD4 count and total lymphocyte count in assessing how well HAART is working for HIV-positive patients. To estimate TlyC in HIV patients before and after starting HAART; to estimate CD4 count in HIV patients before and after starting HAART; to evaluate the relationship between TlyC and CD4 count in HIV patients before and after starting HAART; and to evaluate the accuracy of TlyC as a replacement for CD4 in HIV patients.

Methods: Hospital-based prospective analysis. Consenting HIV-positive HAART patients. ART Centre, Sri Venkateswara Ram Narain Ruia Government General Hospital, Tirupati, Andhra Pradesh, enrols 100 HIV-positive HAART patients from May 2018 to April 2019. ART Centre patients in Tirupati, Andhra Pradesh.

Results: The commonest age group affected is between 20 to 30 years old (40%), followed by 31 to 40 years (33%) with a mean age of 35.19. The study consists of a predominantly female population (63%) compared with males (37%) with Female to male ratio is about 1.7:1. The comments symptoms observed among the study population are weight loss (47%), fever (43%), followed by anorexia (35%). The mean TlyC before HAART is 2195 cells/mm^3 and the mean TlyC after HAART is 2348 cells/mm^3 and which is statistically significant. The mean value of CD4 count before HAART is 561 cells/mm^3 and after HAART is 684 cells/$mm^{3,}$ which is statistically significant. There is a positive correlation between the TlyC and CD4 before HAART (Coefficient= 0.573), as well as after HAART (Coefficient= 0.507).

Conclusion: The current study includes a total of one hundred HIV-positive patients who have agreed to participate. The patients' total lymphocyte counts and CD4 counts were used to evaluate their responses to treatment both before and after six months of HAART treatment. The findings show that the TlyC can be employed as a surrogate marker for CD4 in the evaluation of HAART, particularly in the settings where resources are limited.

Keywords: HAART treatment, HIV patient, lymphocyte counts, CD4, TlyC.

Introduction

The Human Immunodeficiency Virus (HIV) epidemic is a worldwide public health issue. The unfavourable health impact of the acquired immunodeficiency syndrome (AIDS) is profoundly significant for the individual, the family, and society. The prevalence of HIV is increasing at an alarming rate despite advances in research into the virology, pathogenesis, and therapy of HIV as well as opportunistic infections and the development of vaccines [1].

In the United States of America (USA), the first cases of AIDS were discovered. The strange cases of Pneumocystis carinii pneumonia in five previously healthy gay men in Los Angeles and Kaposi's sarcoma in 26 previously healthy gay men in Los Angeles and New York were reported by the Centres for Disease Control and Prevention (CDC) in the summer of 1981. HIV was first identified in a patient with lymphadenopathy in 1983, and by 1984 it had been conclusively determined that the infection was

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 06, 2023

the primary cause of AIDS. The invention of the enzyme-linked immunosorbent assay (ELISA) in 1985 made it possible to appreciate the magnitude and development of the HIV epidemic when it first emerged in the United States and other industrialised countries [2].

The treatment of HIV/AIDS patients in the industrialised world has undergone a revolution since the development of powerful antiretroviral medication in 1996. Treatment with antiretrovirals is not a cure. However, they have significantly reduced mortality and morbidity rates, restored life quality, and changed people's perceptions of HIV/AIDS from a pandemic to a chronic, treatable condition [2]. Unfortunately, the majority of the 40 million people worldwide who have HIV/AIDS live in developing countries and do not exhibit this significantly improved prognosis [3]. Over 4 million people in India are HIV-positive, according to the National AIDS Control Organisation and the Ministry of Health and Family Welfare [4].

The lack of money, knowledge, hospital treatment, and testing facilities in the underdeveloped nations led to the development of the HIV epidemic. The World Health Organisation has modified the current ART regiments with a framework for its application in resource-limited nations, nevertheless, as a result of the efforts of numerous governmental and non-governmental organisations, scientific bodies [1]. Through a number of worldwide initiatives, the cost of highly active antiretroviral therapy (HAART) is drastically falling for low-income countries. Although HAART drugs are readily accessible, it is crucial to create workable solutions for the clinical administration of antiretroviral therapy in settings with constrained resources. The lack of sophisticated and costly laboratory technology and the infrastructure necessary to monitor the success of therapy is one of the major barriers to the delivery of HAART [5]. In industrialized nations, changes in CD4 count and plasma viral load enumeration require highly trained personnel and a high budget for the establishment of laboratory services. In the few resource-limited countries where such laboratory facilities exist, they are often concentrated in major cities, and the assays are too expensive for the majority of patients to use for routine monitoring of HAART [6].

The HIV prevalence in India is only 0.22%. The epidemic in this country is mostly affecting high-risk demographics and is heterogeneously dispersed, with significant spatial diversity in the vulnerabilities that fuel the epidemic. India has the third-highest burden of HIV in the world despite its low incidence, with an estimated 2.14 million individuals living with the disease, 87,000 projected new infections, and 69,000 AIDS-related deaths each year [7]. The purpose of this study is to assess the reliability and clinical utility of TlyC change to serve as a surrogate marker for CD4 count change in monitoring patients on HAART, which has important implications for resource-limited settings.

Materials and Methods

A Hospital-based Prospective Analytical Study. Patients with HIV positive on treatment with HAART who have given consent and fulfilling inclusion and exclusion criteria. 100 patients with HIV positive on treatment with HAART are enrolled during the study period May 2018 to April, 2019 in ART Centre, Sri Venkateswara Ram Narain Ruia Government General Hospital, Tirupati, Andhra Pradesh. Patients attending ART Centre, Sri Venkateswara Ram Narain Ruia Government General Hospital, Tirupati, Andhra Pradesh.

Data Collection

All enrolled patients were informed about the nature of the study, informed written consent was taken before, including them in the study. A detailed history, physical examination, systemic examination, blood samples for Complete blood count, Total Lymphocyte count, CD4 count, Serum creatinine and Liver function test were collected, and other investigations like Sputum for AFB and CB NAAT, Chest X-ray, Ultrasound Abdomen, CT Brain and MRI.

Inclusion Criteria

- Age more than 18 years.
- HIV patients on treatment with HAART.

Exclusion Criteria

- Patients not willing to participating in the study.
- Pregnant women and breast-feeding mothers.

Methods

Blood samples of the patients enrolled in the study were collected for Complete blood count, CD4 count, Total lymphocyte count, Serum creatinine, and Liver function test. Sputum samples were collected for AFB and CB NAAT.

Statistical Analysis

Statistical analysis was one using SPSS software. Chi-square test was used, Correlation coefficient, P values were calculated. P values of <0.05 were considered to be statistically significant.

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Ethical Clearance

Patients were informed about the purpose of the study, and written consent was taken. All investigations were done free of cost, and no financial burden is imposed on patients. No ethical issues are involved. Ethical clearance was obtained from the Institutional Ethics Committee.

Results

The study assessed the 100 HIV positive patients on HAART, with who met inclusion and exclusion criteria are enrolled in the present study. All subjects are evaluated for CD4 count and TlyC before and after HAART, and the results are analyzed.

Age distribution of patients

The mean age of the patient is 35.19 with Standard deviation (SD= 0.99) and with the rage from 20 to 69 years old. The commonest age group affected is between 20 to 30 years old (40%), followed by 31 to 40 years (33%), and 61 to 70 years (1%) is the least frequent age group affected. This is probably due to high-risk behavior in that age group.

Table 1: Age distribution

S. No	Age group (years)	No of patients	Percentage (%)
1	20-30	40	40%
2	31-40	33	33%
3	41-50	19	19%
4	51-60	7	7%
5	61-70	1	1%
Total		100	100%

Sex distribution of patients

The study consists of a predominantly female population (63%) compared with males (37%). Female to male ratio is about 1.7:1. In both sexes, the most frequently observed age category is between 20 to 30 years. There is no female patient between 61 to 70 years in the female group.

Table 2: Sex distribution

S. No	Age group (years)	Sex group			
		Male (n=37)	Percentage (%)	Female (n=63)	Percentage (%)
1	20-30	14	38%	26	41%
2	31-40	11	30%	22	35%
3	41-50	7	18%	12	19%
4	51-60	4	11%	3	5%
5	61-70	1	3%	0	0%
	Total	37	100%	63	100%

Clinical features of patients

The comments symptoms observed among the study population are weight loss (47%), fever (43%), followed by anorexia (35%), and the least common symptom observed is diarrhea (16%). Other clinical features like cough, breathlessness, oral ulcer, malaise, and lymphadenopathy are observed more or less equally.

Table 3: Clinical features

S. No	Clinical features	No of patients	Percentage (%)
1	Fever	43	43%
2	Weight loss	47	47%
3	Anorexia	35	35%
4	Cough	26	26%
5	Lethargy	20	20%
6	Diarrhea	16	16%
7	Oral ulcer	27	27%
8	Breathleness	26	26%
9	Lymphnadenopathy	25	25%
10	Malaise	25	25%
11	Skin ulcer	23	23%

Total Lymphocyte Count of patients before HAART

Total lymphocyte count in the present study ranges from 1060 to 3068 cells/mm^3. Six percent of patients showed their TlyC before HAART is less than 1500 cells/mm^3. Nine percent of patients showed their TlyC before HAART more than 3001 cells/mm^3. Sixty-eightpercent of patients their TlyC before

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HAART between 1500 to 2500 cells/mm^3. The mean TlyC before HAART is 2195 cells/mm^3.

Table 4: TlyC before HAART

S. No	TlyC before HAART (cells/mm^3)	no of patients	P percentage (%)
1	< 1500	6	6%
2	1501-2000	34	34%
3	2001-2500	34	34%
4	2501-3000	17	17%
5	>3001	9	9%
Total		100	100%

Total Lymphocyte Counts of patients after HAART

The lowest TlyC after HAART observed in the present study is 810 cells/mm^3 and highest TlyC after HAART observed in the present study is 3950 cells/mm^3. Four percent of patients showed their TlyC after HAART isless than 1500 cells/mm^3. Twelve percent of patients showed their TlyC after HAART more than 3001 cells/mm^3. Thirty-seven percent of patients showed their TlyC after HAART between 2001 to 2500 cells/mm^3. The mean TlyC after HAART is 2348 cells/mm^3. There is a significant increase in the TlyC after HAART in each group. There is a statistically significance observed in TlyC before and after HAART with a P- value of less than 0.001.

Table 5: TlyC after HAART

S. No	TlyC After HAART (cells/mm^3)	No of patients	Percentage (%)
1	<1500	4	4%
2	1501-2000	26	26%
3	2001-2500	37	37%
4	2501-3000	21	21%
5	>3001	12	12%
Total		100	100

CD4 Count of patients before HAART

CD4 count ranges from 30 cells/mm^3 to 1421 cells/mm^{3}before HAART, and the mean value of CD4 count before HAART is 561 cells/mm^3.

Most of the patients showed their CD4 count more than 301 cells/mm^3 (81%), seven percent of the patients showed their CD4 less than 150 cells/mm^3, eight percentage of the patients showed their CD4 count between 251 to 300 cells/mm^3 before HAART.

Table 6: CD4 count before HAART

S. No	CD4 Count Before HAART (cells/mm^3)	No of patients	Percentage (%)
1	< 150	7	7%
2	151-200	2	2%
3	201-250	2	2%
4	251-300	8	8%
5	>301	81	81%
Total		100	100%

CD4 Count of patients after HAART

There is a drastic improvement in CD4 count after HAART. None of the patients showed their CD4 count after HAART less than 150 cells/mm^3. Ninety-two percent of the patients showed their CD4 count after HAART more than 301 cells/mm^3. Lowest CD4 count after HAART observed is 154 cells/mm^3. The highest CD4 count after HAART observed is 1553 cells/mm^3, and the mean value of CD4 count after HAART is 684 cells/mm^3. There is a statistically significanceis seen in CD4 count before and after HAART with a P- value of less than 0.001.

Table 7: CD4 count after HAART

S. No	CD4 COUNT AFTER HAART (cells/mm^3)	No of patients	Percentage (%)
1	< 150	0	0%
2	151-200	1	1%
3	201-250	3	3%
4	251-300	4	4%
5	>301	92	92%
Total		100	100%

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Comparison of TlyC before and after HAART:

The mean value of TlyC before HAART is 2195 cells/mm^3 (SD=535), with the range from 1060 to 3680 cells/mm^3. The mean value of TlyC after HAART is 2348 cells/mm^3 (SD=569), with the range from 810 to 3950 cells/mm^3. The mean difference in the TlyC before and after HAART is 153 cells/mm^3 (P-value= <0.001) with acorrelation coefficient of 0.610.

Table 8: Chi-square analysis comparing of TlyC before and after HAART

S. No	TlyC Before HAART (cells/mm^3)	No Of Patients	TlyC After HAART (cells/mm^3)	No Of Patients	Pearson Chi- Square	P-value
1	< 1500	6	< 1500	4	69.16	<0.001
2	1501-2000	34	1501-2000	26		
3	2001-2500	34	2001-2500	37		
4	2501-3000	17	2501-3000	21		
5	>3001	9	>3001	12		

Note: P-value <0.05 states that there is a statistically significant difference between the TlyC before and after HAART therapy.

Comparison of CD4 Count before and after HAART:

The mean value of CD4 count before HAART is 561 cells/mm^3 (SD= 273), with the range from 30 to 1421 cells/mm^3. The mean value of CD4count after HAART is 684 cells/mm^3 (SD= 281), with the range from 154 to 1553 cells/mm^3. The mean difference in the CD4 before and after HAART is 122 cells/mm^3, which is statistically significant with a P-value of <0.001 and correlation coefficient of 0.772.

Table 9: Chi-square analysis comparing of CD4 Count before and after HAART Therapy

S no	CD4 Count Before HAART (cells/mm^3)	No of Patients	CD4 Count After HAART (cells/mm^3)	No Of Patients	Pearson Chi-Square	P-value
1	< 150	7	< 150	0	75.84	< 0.001
2	151-200	2	151-200	1		
3	201-250	2	201-250	3		
4	251-300	8	251-300	4		
5	>301	81	>301	92		

Note: P-value <0.05 states that there is a statistically significant difference between the CD4 before and after HAART therapy.

Correlation between TlyC and CD4 count

There is a fair, positive correlation between the TlyC and CD4 before HAART, as well as after HAART (P-value <0.001).

Table 10: Pearson partial correlation coefficient

	TlyC before HAART	TlyC after HAART
CD4 before HAART	Coefficient= 0.573 P-value= <0.001	
CD4 after HAART		Coefficient= 0.507 P-value= <0.001

Discussion

CD4 stands as the gold standard for staging, monitoring, and as a guide to treatment in HIV infected patients, and most importantly, serves as a marker to evaluate the effectiveness of the HAART [8]. However, due to the inadequate availability of resources and the higher cost to estimate the absolute value of CD4, the need for alternative, simple, cost-effective, and relatively accurate markers of disease progression seeks importance, especially in the resource-limited settings. For the former challenge, several studies assessed the various biological marker in place of CD4; TlyC is one among them. Several studies in the past, identified a significant correlation between TlyC and CD4 as a marker for HAART [9-11]. TlyC assessed to be a reliable and cost-effective laboratory investigation, especially in the settings where sophisticated and labor-intensive flow cytometry technique for CD4 is not available [8].

A total of 100 HIV positive patients are enrolled in the present study and assessed their treatment response before and after six months of HAART based on the total lymphocyte count as well as CD4 count.

Age distribution

The mean age of the patient in the present study is 35.19 years (SD= 0.99) and with the range from 20 to 69 years old. The result are similar to other studies done by Fasakin KA *et al*. [12], Anurag Gupta *et al*.

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[13], Preeti Balkisanji Agrawal *et al*. [14], Deresse Daka *et al*. [10], and I M S Darmana *et al*. [11] with the mean age of 37.9±10, 39.5±9, 35.3±8, 32.4±9 and 34±15, respectively. The present study has broder age group, which is inconsistent with the study conducted by I S Darmana *et al*. [11]. In the present study, the majority of the patients (40%) are within the agecategory of20 to 30 years, and the least number of patients are between age group 61 to 70 years. In the study conducted by Alireza Abdollahi *et al*. [15] the majority of the patients, 55%, are within the age category from 28 to 37 years old, and the least number of patients 6% are between age group 48 to 57 years.

Table 11: Age distribution comparison

Study	Mean Age ± SD
Present study	35.2±15
Fasakin KA *et al*. [12]	37.9±10
Anurag Gupta *et al*. [13]	39.5±9
Preeti Balkisanji Agrawal *et al*. [14]	35.3±8
Deresse Daka *et al*. [10]	32.4±9
I M S Darmana *et al*. [11]	34±15

Sex distribution

The present study consists of a predominantly female population (63%) compared with males (37%). Female to male ratio is about 1.7:1. Similar observations were made by Fasakin KA *et al*. [16] and S. Srirangaraj *et al*. [17] (70% and 66% respectively). In contrast to this male predominance observed in the studies conducted by Christian Obirikorang *et al*. [14], Ana luzia *et al*. [18] and Deresse Daka *et al*. [10] (63%, 61% and 57%, respectively).

Table 12: Sex distribution comparison

Study	Sex	
	Male	Female
Present study	37%	63%
Fasakin KA *et al*. [12]	30%	70%
Christian Obirikorang *et al*. [19]	63%	37%
S. Srirangaraj *et al*. [20]	34%	66%
Ana luzia *et al*. [18]	61%	39%
Deresse Daka *et al*. [10]	57%	53%

Clinical Features

In the present study, the most common clinical features are weight loss (47%), followed by fever (43%), and anorexia (35%), and least common symptom observed is diarrhea (16%). Other clinical features like cough, breathlessness, oral ulcer, malaise, and lymphadenopathy are of the same proportion. In similar to our study, the study conducted by Siddeshwar V *et al*. [21] found that the most common clinical feature is fever 72%, followed by weight loss 70% and anorexia 62%. 16% of the patient had diarrhea, and the least common symptom of this study is Malasia 6% and skin infection 4%. The survey conducted by Fasakin KA *et al*. [12], 49.4% were asymptomatic HIV-infected patients.

Table 13: Clinical features comparison

S. No	Clinical features	Present study	Study conducted by Siddeshwar V *et al*.[21]
1	Fever	43%	72%
2	Weight loss	47%	70%
3	Anorexia	35%	62%
4	Cough	26%	28%
5	Lethargy	20%	24%
6	Diarrhea	16%	16%
7	Oral ulcer	27%	16%
8	Breathleness	26%	10%
9	Lymphnadenopathy	25%	10%
10	Malaise	25%	6%
11	Skin ulcer	23%	4%

Total Lymphocyte Count before HAART

Total lymphocyte count in the present study ranges from 1060 to 3068 cells/$mm^{3.}$ Six percent of patients showed their TlyC before HAART is less than 1500 cells/mm^3. Nine percent of patients showed their TlyC before HAART more than 3001 cells/mm^3. Sixty-eightpercent of patients their TlyC before HAART between 1500 to 2500 cells/mm^3. The mean TlyC before HAART is 2195 cells/mm^3.

The studies conducted by Fasakin KA *et al*. [12], Deresse Daka *et al*. [10] and Alireza Abdollahi *et al*. [15], overall mean baseline TlyC count are 1790, 1734, and 1782 cells/mm^3, respectively which is not similar

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to the present study where mean TlyC is higher (2195 cells/mm^3), whereas the study conducted by I M S Darmana *et al*. [11] overall mean baseline TlyC count2018 cells/mm^{3}is similar to the present study.

Table 14: Comparing mean TlyC before HAART

	Mean TlyC
Present study	2195 cells/mm^3
Fasakin KA *et al*. [12],	1790 cells/mm^3
Deresse Daka *et al*. [10]	1734 cells/mm^3
Alireza Abdollahi *et al*. [15]	1782 cells/mm^3
I M S Darmana *et al*. [11]	2018cells/mm^3

Total Lymphocyte Count after HAART

The lowest TlyC after HAART observed in the present study is 810 cells/mm^3, and highest TlyC after HAART observed in the present study is 3950 cells/mm^3. Four percent of patients showed their TlyC after HAART is less than 1500 cells/mm^3. Twelve percent of patients showed their TlyC after HAART more than 3001 cells/mm^3. Thirty-seven percent of patients showed their TlyC after HAART between 2001 to 2500 cells/mm^3. The mean TlyC after HAART is 2348 cells/mm^3. There is a significant increase in the TlyC after HAART in each group. There is a statistically significance observed in TlyC before and after HAART with a P- value of less than 0.001.

The study conducted by Anurag Gupta *et al*. [13], the mean TlyC was 1138 cells/mm^3. For the study conducted by Preeti Balkisanji Agrawal *et al*. [14], the mean (SD) of TlyC was 1324.33 (±441.26) cells/mm^3 and 1721.43(±918.99) cells/mm^3 for subjects less ≤than 30 and ≥ 30-year-old respectively. In comparison, the present study has higher TlyC 2348 cells/mm^3 compared with the other two studies.

Table 15: Comparing mean TlyC after HAART

	Mean TlyC
Present study	2348 cells/mm^3
Anurag Gupta *et al*. [13]	1140 cells/mm^3
PreetiBalkisanji Agrawal *et al*. [14]	1720 cells/mm^3

CD4 Count before HAART

In the present study, lowest CD4 count before HAART observed is 30 cells/mm^3. The height CD4 count before HAART observed is 1421 cells/mm^3 and mean value of CD4 count before HAART 561 cells/mm^3 (SD= 273). Whereas, the study conducted by Fasakin KA *et al*. [12] and Deresse Daka *et al*. [10], overall mean baseline CD4 count 251 and 145 cells/mm^3, which is comparatively lower with themean baseline CD4 of the present study. This is probably due to a higher number of patients had CD4 count <200cells/mm^3 (51.7%) in Fasakin KA *et al*., and 61.3% had CD4 count less than 100cells/mm^{3}in the study of Deresse Daka *et al*.

In the present study, most of the patients showed their CD4 count more than 301 cells/mm^3 (81%), seven percent of the patients showed their CD4 less than 150 cells/mm^3, eight percent of the patients showed their CD4 count between 251 to 300 cells/mm^3 before HAART.

The study conducted by Ana luzia *et al*. [18] reported 17% of the study population had CD4 count <200cells/mm^3, 50% had count between 200 to 500 cells/mm^3, and 33% had count ≥ 500 cells/mm^3. In the study of Deresse Daka *et al*. [10] and Hinta Meijerink *et al*. [22] the, most of the patients showed their CD4 count less than 350 cells/mm^3 97% and 81%, respectively which is in contrast with the present study.

Table 16: Comparing CD4 Count before HAART

	Mean CD4 count
Present study	561 cells/mm^3
Fasakin KA *et al*. [12],	251 cells/mm^3
Deresse Daka *et al*. [10]	145 cells/mm^3

Table 17: Comparing CD4 Count <200 cells/mm^3

	CD4 count <200 cells/mm^3
Present study	9%
Fasakin KA *et al*. [12],	52%
Ana luzia *et al*. [18]	17%
Deresse Daka *et al*. [10]	75%
Hinta Meijerink *et al*. [22]	66%

CD4 Count after HAART

There is a drastic improvement in CD4 count after HAART. None ofthe patients showed their CD4 count

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after HAART less than 150 cells/mm^3. Ninety-two percent of the patients showed their CD4 count after HAART more than 301 cells/mm^3. Lowest CD4 count after HAART observed is 154 cells/mm^3. The highest CD4 count after HAART observed is 1553 cells/mm^3, and the mean value of CD4 count after HAART is 684 cells/mm^3. There is a statistically significanceis seen in CD4 count before and after HAART with a P- value of less than 0.001.

In the study conducted by Fasakin KA *et al.* [12], after six months of HAART, 72.8% had a CD4 count of ≤350cells/mm^3. The study conducted by Anurag Gupta *et al.* [13], 80% of the subjects had <350 cell/mm^3 though these are not correlating with the present study, but improvement in the CD4 count was observed in both the studies.

Table 18: Comparing CD4 Count <300 cells/mm^3

	CD4 count <300 cells/mm^3
Present study	92%
Fasakin KA *et al.* [12],	73%
Anurag Gupta *et al.* [13]	80%

Correlation of CD4 count and TlyC before and after HAART

All the studies, including the present study, showed a statistically significant correlation between the CD4 and TlyC before and after the HAART. Sonali Jain *et al.* [23] (r= 0.77), Fasakin KA *et al.* [28] (r= 0.65), Anurag Gupta *et al.* [13] (r= 0.68), Christian Obirikorang *et al.* 19 (r= 0.57), S. Srirangaraj *et al.* [31] (r= 0.56) and Ana luzia *et al.* [18] (r= 0.58), were showed significant stronger correlation between the CD4 count and TlyC before and after the HAART in their studies. The similar observations are found in the present study (r= 0.57).

On the other hand, the study conducted by Preeti Balkisanji Agrawal *et al.* [27] (r= 0.32) and Deresse Daka *et al.* [10] (r= 0.39) showed a weaker correlation.

However, on the whole, all the studies mentioned above showed a statistically significant correlation between CD4 count and TlyC. The result are suggesting that the TlyC can be used as a surrogate marker for CD4 in the assessment of HAART, especially in the resource-constrained settings.

Table 19: Comparing correlation of CD4 and TlyC

Study	**R-value (P-value<0.05)**
Present study	0.57
Fasakin KA *et al.* [12]	0.65
Anurag Gupta *et al.* [13]	0.68
Preeti Balkisanji Agrawal *et al.* [14]	0.32
Christian Obirikorang *et al.* [19]	0.57
S. Srirangaraj *et al.* [20]	0.56
Ana luzia *et al.* [18]	0.58
Sonali Jain *et al.* [23]	0.77
Deresse Daka *et al.*10	0.39

Conclusion

In the current study, there are a total of one hundred HIV-positive patients who have been enrolled, and their treatment response has been evaluated based on their total lymphocyte count in addition to their CD4 count before and after six months of HAART treatment. The findings imply that the TlyC can be utilised in the evaluation of HAART as a surrogate marker for CD4, particularly in areas where resources are limited.

Funding Support: Nil

Conflict of interest: None

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