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ORIGINAL ARTICLE

Effectiveness of first-line antiretroviral therapy in HIV/AIDS patients: A 5-year longitudinal evaluation in Fujian Province, Southeast China

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Abstract The aim of this study was to evaluate the long-term effectiveness of first-line antiretroviral therapy in HIV/AIDS patients in Southeast China. A total of 450 eligible patients were selected to initiate first-line antiretroviral therapy from February 2005 through August 2009. During the study period from 2009 through 2013, each subject received clinical and laboratory monitoring for effectiveness, safety and toxicity once every 3 months in the first year, and once every 6 months in the following years. The response to first-line antiretroviral therapy was evaluated through body weight gain and immunological and virological outcomes. During the mean follow-up period of 70.86 ± 28.9 months, the overall mortality was 14.2 %. The mean body weight and $CD4^+$ counts increased significantly following antiretroviral therapy as compared to baselines across the follow-up period, and the rate of immunological effectiveness was over 85 % in all subjects at 2 to 5 years of treatment. The rate of inhibition of HIV virus was 87.67 %, 89.32 %, 91.73 %, 92.8 % and 91.63 % across the study period. In addition, significant differences were detected after treatment as compared to baselines, and Pearson correlation analysis revealed a positive correlation between immunological effectiveness and viral inhibition. Forty-eight percent of the subjects changed antiretroviral drugs once, and 16.22 % twice, and 31 patients switched from first-line to second-line antiretroviral therapy. Long-term antiretroviral therapy remains effective for treatment of HIV/AIDS, resulting in higher mean body weight, effective viral inhibition and a higher CD4 count. Immunological effectiveness of antiretroviral therapy positively correlates with HIV viral inhibition.

Introduction

Acquired immunodeficiency syndrome (AIDS), caused by human immunodeficiency virus (HIV), continues to be a major global public-health and social issue. In 2013, there were 35 million people living with HIV/AIDS, and it was estimated that 1.5 million died of AIDS-related diseases worldwide [1]. In China, AIDS remains a big challenge to public health and has been defined as one of the priorities for communicable-disease control by the central government [2]. It was estimated that a total of 436,800 people were living with HIV or AIDS in China by the end of 2013, and 136,300 had died from the disease [3].

Currently, there is no cure for HIV infection or AIDS [4]. However, effective antiretroviral therapy is found to sustain suppression of HIV replication and reconstitution of the immune response [5, 6], and this leads to a dramatic decrease in AIDS-related morbidity and mortality [7–9].

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Since effective treatment with antiretroviral drugs can control the virus, people living with HIV/AIDS can enjoy healthy and productive lives [10]. Based on the standard World Health Organization (WHO) clinical and laboratory criteria, people with stage III/IV disease and/or a CD4 count of < 200 cells/ml require antiretroviral therapy [11].

China's national free antiretroviral treatment program began in 2003 [12]. Initial implementation and scale-up of the free antiretroviral treatment concentrated on former blood donors in the central provinces [13]. Since 2005, however, with the changes in the HIV/AIDS epidemic, the treatment coverage has extended across the country, and more and more HIV/AIDS patients who acquired the virus via sex and drug use are included in the program [14]. At the end of 2009, a total of 80,000 patients in China were estimated to be receiving antiretroviral therapy [15, 16]. However, following the extensive implementation of antiretroviral treatment, there is great concern about the emergence of drug-resistant HIV strains [17]. HIV drug resistance is considered one of the strongest predictors of treatment failure [18–20], since it can render existing therapies ineffective, thereby increasing the risk of viral rebound and opportunistic infections [21–23]. Therefore, a national HIV drug resistance surveillance and monitoring network was established in China in 2004 in order to monitor the development of resistance of HIV strains to antiretroviral agents [24]. In China, the prevalence of drug-resistant HIV strains has been reported to increase with the continuation of antiretroviral therapy [25], and in Henan province of central China, the prevalence of drug-resistant HIV strains was found to increase sharply from 17.6 % to 45.4 % and 62.3 % in patients undergoing antiretroviral therapy beyond three and six months, respectively [26].

In Fujian province, southeast coast of mainland China, HIV is predominantly transmitted through sexual contact [27]. Since 2005, free antiretroviral therapy has been implemented for HIV/AIDS patients across the province [28]. During the 10-year period from 2005 to 2014, a total of 3158 patients had been treated, and there are still 2708 patients undergoing treatment. In the current study, a 5-year longitudinal evaluation was carried out with aim of assessing the long-term effectiveness of first-line antiretroviral therapy through monitoring of clinical, immunological and virological parameters in HIV/AIDS patients in Fujian Province, Southeast China.

Subjects and methods

Subjects

During the period from February 2005 through August 2009, 450 treatment-naïve patients who met the inclusion criteria of the Chinese national antiretroviral treatment guidelines were selected for antiretroviral therapy. These included a $CD4^+$ T lymphocyte (CD4) count of < 200 cells/μl, a total lymphocyte count of < 1200 cells/μl, or HIV clinical stage III/IV according to the World Health Organization [11, 16] Each subject was evaluated prior to initiation of antiretroviral therapy. For those receiving antiretroviral therapy, subsequent clinical and laboratory monitoring for effectiveness, safety and toxicity was performed once every 3 months in the first year, and once every 6 months in the following years. Among the 450 patients, 345 (76.7 %) were followed up for 5 years or longer, while 105 (23.3 %) dropped out of treatment during the follow-up period due to death (64, 14.2 %), withdrawal (14, 3.1 %), transfer to other provinces (18, 4.0 %), and loss of follow-up (9, 2.0 %).

Treatment protocol

According to the WHO recommendations on antiretroviral therapy for HIV infections [11], the first-line antiretroviral therapy consisted of two nucleoside reverse transcriptase inhibitors (NRTIs) and one non-nucleoside reverse transcriptase inhibitor (NNRTI), including zidovudine (AZT) or stavudine (d4T) + lamivudine (3TC) + nevirapine (NVP) or efavirenz (EFV). This regimen, however, was not employed until 2005, when 3TC was market-available in China. As a result, 15 patients received antiretroviral therapy on initial treatment, including seven patients (1.56 %) treated with a didanosine (ddI) regimen (DDI + 3TC + EFV for one case, DDI + D4T + NVP for 5 cases, and DDI + AZT + NVP for one case) and eight patients (1.78 %) treated with indinavir (IDV) regimen (3TC + IDV + D4T for 4 cases, 3TC + IDV + AZT for one case, Atripla + IDV for one case, and EFV + IDV for 2 cases). The second-line antiretroviral therapy consisted of two NRTIs + a ritonavir-boosted protease inhibitor (PI), TDF/AZT + 3TC + lopinavir/ritonavir (LPV/r).

Laboratory tests

At baseline and each follow-up visit, all subjects were weighed, interviewed about their adherence to therapy and treatment-related side effects and asked to provide blood specimens. These specimens were used to measure the CD4 count and viral load and for routine blood and liver function testing. The main information collected included gender, age, and the probable route of infection.

The HIV diagnosis was confirmed using a Western blot assay (MP Diagnostics™ HIV BLOT 2.2, MP Biomedicals, Asia Pacific Pte. Ltd., Singapore). Patients were considered anti-HIV-1 antibody positive if the following two criteria were met: (1) presence of at least two env

bands (gp41 and gp160/gp120) or simultaneous emergence of at least one env band and p24 band and (2) meeting the diagnostic criteria proposed by the manufacturer of the Western blot kit [14].

The CD4 count was measured using a BD TriTEST™ CD3-FITC/CD4-PE/CD45-PerCP Kit (BD Biosciences; Franklin Lakes, NJ, USA) on a BD FACSCalibur system (BD Biosciences; Franklin Lakes, NJ, USA). The plasma HIV-1 RNA concentration was determined using a Versant® HIV-1 RNA 3.0 Assay (bDNA; Bayer HealthCare; Tarrytown, NY, USA) on a Bayer Versant® 340 bDNA Analyzer (Bayer HealthCare; Tarrytown, NY, USA) following the manufacturer's instructions.

Assessment of efficacy of antiretroviral therapy

The efficacy of the antiretroviral therapy provided to patients was assessed using the WHO criteria for clinical, immunological and virological failure. As the most sensitive indicator for demonstrating the efficacy of antiretroviral therapy against HIV [29], body weight gain was used in this study to evaluate the response to antiretroviral therapy. The criteria for immunological failure included a CD4 count drop to < 100 cells/mm^3, a 50 % reduction in baseline CD4 from the treatment peak value, or a decrease to the baseline CD4 level or below, and the criterion for virological failure was a plasma viral load of more than 1000 copies/ml when the patient had received antiretroviral therapy for at least 6 months [30].

Genotypic testing of HIV-1 drug resistance

Samples with an HIV viral load of 1000 copies/ml or greater were selected for HIV-1 drug resistance testing by using an in-house RT-PCR protocol as described previously [31]. To detect HIV drug resistance mutations, the HIV-1 *pol* gene (protease amino acids 1–99 and reverse transcriptase amino acids 1–252) was amplified, and its sequence was compared to those in the Stanford HIV Drug Resistance Database (http://hivdb.stanford.edu/). We included mutation results that conferred low-, intermediate- and high-level resistance.

Ethical considerations

This study was approved the Ethics Review Committee of Fujian Provincial Center for Disease Control and Prevention (permission no. FJCDCERC-2004004). Written informed consent was obtained from all participants with a detailed description of the purpose and potential benefits of this study, and the confidentiality of the respondents' information and blood test results was guaranteed.

Statistical analysis

All measurement data were expressed as mean ± standard deviation (SD), and all statistical analysis was performed using the statistical software SPSS version 15.0 (SPSS Inc.; Chicago, IL, USA). Differences in mean values among groups were tested for statistical significance by one-way analysis of variance (ANOVA), while comparisons of mean values between groups was done by Student's *t*-test. The association between immunological effectiveness and viral inhibition was evaluated using Pearson correlation analysis. A *P*-value less than 0.05 was considered statistically significant.

Results

Demographic and clinical characteristics of patients receiving antiretroviral therapy

The 450 HIV/AIDS patients undergoing antiretroviral therapy included 300 men (66.7 %) and 150 women (33.3 %), and the mean age was 45.24 ± 10.92 years (range, 21 to 82 years). Of these patients, 65.6 % were from 30 to 50 years old. Among the 450 subjects, 69.1 % were married or cohabiting, and 76 % were infected with HIV through sexual contact (2.4 % homosexual transmission and 73.6 % heterosexual transmission). There were 302 patients (67.1 %) with a CD4 count of < 150 cells/mm^3 on admission (Table 1).

Follow-up and survival of patients receiving antiretroviral therapy

All subjects had a mean follow-up period of 70.86 ± 28.9 months. There were 377 subjects who were followed up for 5 year or longer, with a 2 % loss to follow-up, and 345 subjects are still under therapy, with 76.7 % adherence to therapy. The overall mortality was 14.2 % (64/450) during the entire follow-up period, with the most deaths observed within the first year post-treatment (51.6 %), indicating a reduction in deaths due to HIV/AIDS during the treatment period (Table 2).

Change of body weight caused by antiretroviral therapy

During the follow-up period, the mean body weight of the patients increased significantly each year following antiretroviral therapy as compared to baseline (all *P*-values < 0.001), with the greatest increase (5.26 %) seen in the second year of therapy. Over 60 % of the patients showed an increase in body weight during the follow-up

Table 1 Demographic and clinical characteristics of the subjects

Parameter		No. of patients	Percentage (%)
Gender	Male	300	66.7
	Female	150	33.3
Married status	Unmarried	61	13.6
	Married or cohabiting	311	69.1
	Divorced or separated	41	9.1
	Widowed	36	8.0
	Unknown	1	.2
Referred risk	Blood transfusion	6	1.3
	Plasmapheresis	1	.2
	Intravenous drug use	35	7.8
	Homosexual transmission	11	2.4
	Heterosexual transmission	331	73.6
	Unclear	61	13.6
	Unknown	5	1.1
Age group (years)	< 30	18	4.0
	30–50	295	65.6
	≥ 50	137	30.4
CD4 count (cells/mm^3)	< 150	302	67.1
	150–200	55	12.2
	≥ 200	71	15.8
	Unknown	22	4.9
WHO clinical stage at treatment	I	86	19.1
	II	142	31.6
	III	158	35.1
	IV	15	3.3
	Unknown	49	10.9

Table 2 Follow-up and survival of the subjects

Duration of treatment (year)	No. of subjects	Loss to follow-up	Death	Transfer to other provinces	Drug withdrawal	No. of patients under therapy	Survival rate (%)	Percentage of adherence to therapy (%)
Baseline	450	1	33	0	6	410	92.7	91.1
1	410	2	9	0	1	398	89.1	88.4
2	398	0	3	0	0	395	99.2	87.8
3	395	2	7	0	0	386	86.2	85.8
4	386	2	2	0	5	377	85.3	83.8
≥5	377	2	10	18	2	345	81.6	76.7

period. One-way ANOVA revealed a significant difference in the mean body weight during the 5-year follow-up period ($F = 15.66$, $P < 0.001$); however, no significant differences were seen in the body weight between years (Table 3).

Immunological outcome of antiretroviral therapy

Following antiretroviral therapy, CD4 counts increased significantly, compared to those at baseline (all P-values < 0.001), as revealed by paired t-test. In the first year of antiretroviral therapy, the mean CD4 count increased by 147 cells/mm^3, and it increased by over 200 cells/mm^3 in the following 4 years, with the greatest increase (293 cells/mm^3) detected following the 5-year treatment (Fig. 1A). During the 5-year treatment period, the number of patients with CD4 count elevation of > 150 cells/mm^3 gradually increased with the extension of treatment, from 39.24 % in the first year to 75.07 % in the fifth year of treatment. There was a significant difference in CD4 count for the different years of treatment ($F = 294.2$, $P < 0.001$). The mean CD4 count increased from 116.41 cells/mm^3 at

Table 3 Changes in body weight during the 5-year follow-up

Body weight	Follow-up				
	First year ($n = 384$)	Second year ($n = 365$)	Third year ($n = 342$)	Fourth year ($n = 316$)	Fifth year ($n = 279$)
Mean follow-up period (months)	21.56 ± 2.06	33.61 ± 1.94	45.45 ± 2.15	57.60 ± 1.89	80.94 ± 16.13
Mean baseline body weight (kg)	56.58 ± 9.32	56.51 ± 9.21	56.37 ± 9.12	56.34 ± 8.78	55.96 ± 8.90
Mean body weight during follow-up (kg)	59.09 ± 8.97	59.50 ± 14.46	58.91 ± 8.78	59.02 ± 9.26	58.19 ± 9.04
t-value	8.01	4.66	7.74	7.38	5.58
P-value	<0.001	<0.001	<0.001	<0.001	<0.001
Mean body weight gain (kg)	2.49	2.98	2.54	2.69	2.22
Percent body weight gain	4.41	5.26	4.51	4.77	3.97
No. of patients with body weight gain	244.00	224.00	210.00	204.00	168.00
Percentage of patients with body weight gain	63.54	61.37	61.40	64.56	60.22

baseline to 413.54 cells/mm^3 following 5 years of antiretroviral therapy (Fig. 1B). Except for years four and five of treatment, there were significant differences in the mean CD4 count between the years of treatment and between the year of treatment and baseline. According to the WHO criteria for identification of immunological failure, the highest rate (19.24 %) of immunological failure was observed in the first year of antiretroviral therapy, and the rate was uniformly < 15 % in the following four years, indicating over 85 % immunological effectiveness (Table 4).

Virological outcome of antiretroviral therapy

Our findings showed that antiretroviral therapy resulted in a marked inhibition of HIV replication, and the percentage of HIV viral inhibition (< 1000 copies/ml) was 87.67 % following one-year treatment. The rate of viral suppression was found to increase with the continuation of antiretroviral therapy and reached 91.63 % after 5 years of treatment. Pearson correlation analysis revealed that the immunological effectiveness was associated with viral inhibition 2, 3, 4 and 5 years post-therapy (all P values < 0.01), while no correlation was detected in the first year of treatment ($R = 0.135$, $P = 0.104$) (Table 5).

Change of treatment regimen and drug resistance

During the follow-up period, 216 patients (48 %) changed their antiretroviral treatment regimen once, predominantly because of adverse effects (71.76 %), and to a much lesser extent because of to treatment failure (only 4.63 %). With the extension of first-line antiretroviral therapy, 73 subjects (16.22 %) changed their antiretroviral agents twice, mainly because of side effects (61.64 %), and the rate of treatment failure increased to 13.7 % among these patients. During the follow-up period, 31 patients (8.98 %) switched to second-line antiretroviral therapy, including 25 patients (5.56 %) due to resistance to first-line antiretroviral therapy. HIV-1 drug resistance testing revealed resistance to multiple NRTIs and NNRTIs at various levels, but the HIV-1 strains remained susceptible to PIs. Treatment with PI-containing regimens continued to result in viral inhibition.

Discussion

Although antiretroviral therapy is not a cure for HIV/AIDS, most HIV-infected individuals without treatment will eventually develop progressive immunosuppression, leading to AIDS-defining illnesses and premature death [1]. The major purpose of antiretroviral therapy is to prevent HIV-associated morbidity and mortality [32]. Effective antiretroviral therapy may reduce the HIV viral load, improve immune function, delay the onset of AIDS, enhance the quality of life, lower the risk of both AIDS-defining and non-AIDS-defining complications, and reduce the impact of HIV transmission in the community [33, 34]. Following long-term, extensive, repeated application of antiretroviral therapy, however, there is an increasing prevalence of HIV drug resistance [35–37]. It is therefore of great importance to monitor the effectiveness of first-line antiretroviral therapy in regions where the treatment regimen is widely implemented, because firstly, there is concern that continued use of antiretroviral therapy may give rise to populations of drug-resistant HIV strains, and secondly, the treatment regimens may be intermediately changed if drug resistance is detected.

Worldwide, a high level of HIV drug resistance has been reported among patients undergoing first-line antiretroviral therapy, notably in African countries [37–41]. In China, an increasing prevalence of drug resistance has been detected among HIV/AIDS patients with first-line antiretroviral

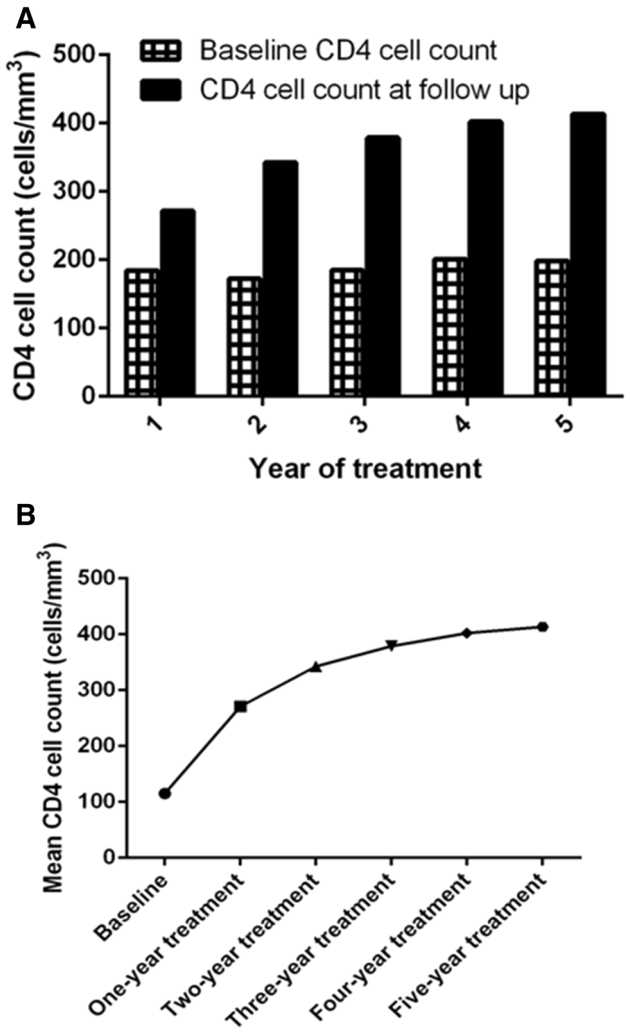

Fig. 1 Determination of CD4 count by flow cytometry. A, comparison of mean CD4 cell count 1 to 5 years after antiretroviral therapy vs. baseline; B, mean CD4 cell count 1 to 5 years after antiretroviral therapy

therapy. In Hubei province, the prevalence of NRTI- and NNRTI-resistance mutations was 24.3 %, 57.1 % and 63.3 % at 3-6, 9-12, and 20-24 months post-treatment, respectively [42]. Data from the Chinese National HIV Drug Resistance Surveillance and Monitoring Network between 2003 and 2012 showed that the proportion of patients with drug resistance to NNRTIs, NRTIs and PIs was 52.9 %, 76.5 % and 4.4 %, respectively [43]. Among the 718 HIV-1-infected individuals with first-line antiretroviral therapy living in the provinces of Henan, Heilongjiang, Jilin, Liaoning, Neimenggu, Shanxi and Yunnan, the overall prevalence of drug-resistance mutations was 37.8 % [44]. A recent meta-analysis to describe the trends in emergent HIV drug resistance to first-line antiretroviral therapy among Chinese HIV-infected patients revealed that the pooled prevalence of HIV drug resistance from longitudinal cohort studies was 10.79 % and 80.58 % after 12 and 72 months of antiretroviral therapy, and the pooled prevalence of HIV drug resistance increased from 11.1 % after 0-12 months to 22.92 % after 61-72 months of antiretroviral therapy [25]. Until now, however, there has been little information on the effectiveness of and resistance to first-line antiretroviral therapy among HIV/AIDS patients in Fujian Province, Southeast China. The current study was therefore, in a longitudinal cohort, designed to evaluate the 5-year effectiveness of first-line antiretroviral therapy among HIV/AIDS patients.

In the current study, the longitudinal cohorts had a mean follow-up period of 70.86 ± 28.9 months, 83.8 % were followed up for 5 years or longer, and 76.7 % adhered to antiretroviral therapy. Across the follow-up period, the overall mortality was 14.2 %, with deaths predominantly observed during the first year of treatment (51.6 %). It has been demonstrated that early initiation of antiretroviral therapy lowers mortality in HIV-infected patients [45–47]. Previous studies have demonstrated that a high baseline CD4 cell count is associated with a low risk of AIDS-associated illness and death among HIV patients initiating antiretroviral therapy [48–51]. Therefore, the central government of China has gradually increased the absolute CD4 count cutoff from 200 cells/mm^3 in 2005 to 350 cells/mm^3 in 2012 and 500 cells/mm^3 in 2015 for patients starting antiretroviral therapy [52, 53].

In this study, the efficacy of antiretroviral therapy was evaluated using body weight, CD4 count and HIV viral load. A 5-year follow-up showed that antiretroviral therapy markedly suppressed HIV replication, improved immune function, and increased body weight. In addition, a significant correlation was observed between immunological effectiveness and viral inhibition following antiretroviral therapy, except the first year, suggesting that the elevation in CD4 count was consistent with the decline in HIV viral load in most patients undergoing antiretroviral therapy. However, inconsistency was observed in some patients between immunological and virological outcomes following antiretroviral therapy, which may be attributed to age, baseline viral load, baseline CD4 count, treatment regimen, or adherence to therapy. Such a postulation is consistent with previous reports, demonstrating that the patient's characteristics (such as age, viral load and CD4 count), treatment regimens and adherence affected the immunological and virological response to antiretroviral therapy [54–60].

Our findings showed that the change of first-line antiretroviral treatment regimens was mainly due to drug-related side effects, and the switch to second-line antiretroviral therapy was predominantly due to failure of first-line antiretroviral treatment due to drug resistance. HIV drug resistance testing showed resistance to NRTIs

Table 4 Changes of $CD4^+$ cell count during the 5-year follow-up

Body weight	Follow-up				
	First year	Second year	Third year	Fourth year	Fifth year
No. of subjects	395	369	365	357	345
Mean CD4+ cell count during follow-up (cells/mm^3)	271.25 ± 184.17	342.85 ± 172.10	378.88 ± 184.98	402.34 ± 201.22	413.54 ± 198.56
Mean baseline $CD4^+$ cell count (cells/mm^3)	116.41 ± 125.55	119.19 ± 129.04	119.99 ± 131.74	119.77 ± 130.75	118.36 ± 130.14
Increase in $CD4^+$ cell count (cells/mm^3)	147.06	216.66	257.16	277.41	292.79
Percent increase in $CD4^+$ cell count	126.33	181.77	214.31	231.62	247.38
t-value	17.38	25.36	27.23	26.71	27.22
P-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Percent increase in $CD4^+$ cell count > 150 cells/ml	39.24	60.16	68.77	70.03	75.07
Immunological effectiveness (%)	80.76	87.26	87.67	88.80	87.83

Table 5 Effect of antiretroviral therapy on HIV viral load

Duration of treatment (years)	No. of patients	No. of patients tested	Percent tested	Rate of viral inhibition < 1000 copies/ml (%)	Correlation between immunological effectiveness and viral inhibition	
					R	*P*
1	410	146	35.61	87.67	0.135	0.104
2	398	206	51.76	89.32	0.320	0.000
3	395	254	64.30	91.73	0.192	0.002
4	386	264	68.39	92.80	0.247	0.000
5	377	251	66.58	91.63	0.191	0.002

and NNRTIs at various levels, similar to other reports from China [61–63]. This may be associated with the wide implementation of free therapy with two NRTIs and one NNRTI. With the initiation of second-line antiretroviral therapy, more and more HIV/AIDS patients with failure in first-line therapy switch to a second-line antiretroviral therapy that includes PIs. Therefore, there is a high risk of emergence and spread of PI-resistant HIV strains, to which much attention should be paid. Follow-up of drug-resistant patients showed that low adherence to antiretroviral therapy was the major cause of HIV drug resistance. An assessment of the adherence to the therapy is therefore recommended prior to switching to second-line antiretroviral therapy, and the adherence to second-line antiretroviral therapy should be improved. Otherwise, drug resistance, or even treatment failure is unavoidable even if second-line antiretroviral therapy is employed.

The results suggest that the efficacy of currently recommended free first-line antiretroviral drugs remains satisfactory for the treatment of HIV/AIDS in Fujian Province, Southeast China; however, we cannot ignore the emergence and spread of drug-resistant HIV strains of drug-resistant strains, which may be detrimental for the sustainability of the therapy.

Conclusions

The results of this study demonstrate that the long-term efficacy of first-line antiretroviral therapy against HIV/AIDS appears satisfactory in Fujian Province, Southeast China, and the therapy is effective for increasing body weight, reducing the HIV viral load, and increasing the CD4 count. However, treatment failure and drug resistance were still detected. We therefore should not reduce our vigilance regarding the emergence of drug-resistant HIV strains. Fortunately, drug resistance can be easily detected [64–66]. Further periodical studies monitoring both the efficacy of first-line antiretroviral therapy and the development and epidemiology of drug-resistant HIV strains in Fujian province are still required. If resistance to first-line antiretroviral therapy is detected in HIV/AIDS patients, second-line antiretroviral therapy should be implemented immediately to delay the progression of HIV-associated illness and prevent the spread of HIV drug resistance.

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Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to disclose.

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