ORIGINAL PAPER

Effects of HIV infection on clinical and laboratory characteristics of sickle cell disease among patients in Homa Bay County Hospital, Kenya

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Abstract

Introduction: This investigation provided insights on the clinical, laboratory, and nutritional characteristics in human immunodeficiency virus (HIV) and sickle cell disease (SCD) comorbidity. Information gained from this study have the potential to inform tailored and optimized healthcare approaches, ultimately enhancing the overall management and well-being of HIV-SCD patients.

Material and methods: Conducted at the Homa Bay County Teaching and Referral Hospital in Kenya, this retrospective cohort study examined the effects of HIV infection on clinical, laboratory, and nutritional characteristics in HIV and SCD comorbidity. The research involved 101 HIV-positive SCD patients and 102 HIV-negative SCD patients, aged 2 to 17 years. This study aimed to understand the effect of HIV infection on SCD presentation. Data encompassed demographics, medical history, laboratory results, and nutritional assessment using weighing scale.

Results: The study highlighted a significant clinical, laboratory, and nutritional association in HIV infection with SCD. HIV-positive participants had 1.26 times higher odds of vaso-occlusion ($p < 0.0001$), 1.14 times more infections ($p < 0.0001$), 1.28 times higher odds of developing neuropathy ($p < 0.0001$), and 1.29 times higher chance of suffering from splenic sequestration ($p < 0.0001$). HIV-SCD comorbidity was 1.332 times higher ($p < 0.0001$), and pain incidence was over 2 times more frequent ($p = 0.0142$). Laboratory data showed that HIV-infected SCD patients were 1.53 times more likely to suffer from anemia ($p < 0.0001$), 1.25 times more likely having higher mean corpuscular volume ($p < 0.0001$), 1.26 times more likely to suffer from platelets deficiency ($p < 0.0001$), and 1.2 times more probable to suffer from low neutrophil count ($p < 0.0001$). Whereas among HIV-negative SCD participants, this was 1.222 (95% CI: 1.113-1.435), with $p < 0.0001$. A statistically significant relationship between neutrophil count and HIV status was found, showing that HIV-negative SCD patients were more likely to have high neutrophils count compared with HIV-negative SCD patients. Nutritional status assessment using weighing scale revealed that HIV-positive SCD patients were 1.39 more likely to be underweight ($p < 0.0001$). Nutritional outcomes showed HIV-negative individuals were 1.601 times more likely to have normal weight than being underweight ($p < 0.001$), while overweight likelihood was not significant ($p = 0.174$).

Conclusions: This study holds significance in adopting the best model of care for patients with HIV and SCD comorbidity, which may influence their frequent hospitalization, use of medication, i.e., antibiotic prophylaxis and vaccination.

HIV AIDS Rev 2026; 25, 3: 228-233
DOI: https://doi.org/10.5114/hivar/186704

Key words: sickle cell disease, HIV, comorbidity, clinical, laboratory, characteristics.

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Article history:
Received: 03.11.2023
Revised: 28.11.2023
Accepted: 02.04.2024
Available online: 10.06.2026

International Journal of HIV-Related Problems
HIV & AIDS Review

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Introduction

Sickle cell disease (SCD) is a hereditary blood disorder, characterized by the presence of abnormal hemoglobin, primarily hemoglobin S (HbS), which causes red blood cells to adopt a distorted shape [1]. This deformation leads to various clinical complications, including vaso-occlusive crises, hemolytic anemia, and organ damage [2]. SCD is particularly prevalent in sub-Saharan Africa, where an estimated 75% of global SCD cases occur [3]. Concurrently, this region also bears a substantial burden of human immunodeficiency virus (HIV) infection [4], making it crucial to explore potential interactions between these two health conditions and their impact on clinical and laboratory features.

HIV infection remains a critical global health challenge [5], with sub-Saharan Africa accounting for approximately two-thirds of new HIV infections worldwide [6]. Immunological disturbances and chronic inflammation induced by HIV infection could potentially intersect with the underlying inflammatory processes in SCD [7, 8]. This interaction might lead to altered disease trajectories and clinical presentations. Despite the co-existence of these two conditions in the same population, there is a lack of comprehensive research investigating the combined effects of HIV infection on the clinical and laboratory manifestations of SCD.

This study aimed to address this gap in knowledge by examining the effects of HIV infection on the clinical and laboratory characteristics of SCD individuals. By systematically analyzing clinical outcomes, such as infections [9, 10], vaso-occlusive events [11], splenic sequestration, neuropathy, and pain, along with laboratory parameters, including neutrophils count, platelet count, mean corpuscular volume (MCV), and hematocrit, this research attempted to unfold the complex interplay between SCD and HIV infection. Understanding how these conditions interact can offer valuable insights into disease progression, management strategies, and potential avenues for therapeutic interventions [12].

The convergence of SCD and HIV infection in sub-Saharan Africa prompts an exploration of their interrelationship and its consequences for affected individuals. This study endeavored to shed light on how HIV infection influences the clinical and laboratory characteristics of individuals with SCD, potentially paving a way for improved clinical management and interventions addressing the unique challenges posed by the co-existence of these two conditions.

Material and methods

Study design, setting, and period

This was a retrospective cohort study conducted at the Homa Bay County Teaching and Referral Hospital, Homa Bay County. This site was selected based on the number of SCD patients load, and participants were enrolled from both SCD clinic and comprehensive care clinic. These clinics operate five days a week with a patient flow of at least 30 per day for SCD clinic.

Study population

Study cohort included HIV-infected individuals with concomitant SCD. A retrospective cohort design was employed, focusing on children aged 2 to 17 years with HIV-SCD co-infection. Study sample was extracted from a population of around 126 individuals affected by the dual condition, receiving care at the SCD clinic within the Homa Bay Teaching and Referral Hospital, Kenya. Inclusion criteria were children aged 2 to 17 years, who had attended both HIV and SCD clinics for a minimum of 6 months. Only participants providing informed consent or assent were enrolled. Exclusion criteria encompassed children aged below 2 years and over 17 years, in addition to participants residing outside the study area or declining participation.

Sample size determination and sampling procedure

Study sample size was determined according to Yamane's (1967) formula, as follows:

$$n = N/(1 + N\,(e^2)),$$

where n is the required sample size, N is the population, and e is the precision at 95% confidence. This yielded 96 participants ($n = 126/[1 + 126\ (0.05)^2] = 96$), later adjusted to 106 for non-respondents. An equal number of HIV-exposed and unexposed SCD patients was ensured. Respondents were systematically selected, starting randomly and subsequent participants were chosen at intervals. Interval calculation: dividing pre-study care individuals (126) by sample size (106), resulting in 1.2 (126/106 = 1.2). This process continued in each clinic's day, until 106 was reached. One control was selected per participant, except for SCD, meeting study criteria.

Data collection

Before commencing data collection, a research tool's reliability and validity were ensured. A panel of experts assessed the tool's items for relevance and clarity. Cronbach's α coefficient established item inter-relation for reliability. Pre-testing was conducted among nearly 5% of the broader population to evaluate the tool's effectiveness beyond the study area. Both primary and secondary data were gathered. Demographics, clinical history, laboratory results, and nutritional aspects were collected using questionnaires. Clinical diagnoses and past year's laboratory tests were sourced from hospital records. Caregivers aided in reporting minors' clinical history when they were not able to provide accurate accounts.

Study variables

The study examined the effects of dependent variable, i.e., HIV infection, on a number of independent variables classified into three groups, including clinical characteristics, nutritional and growth factors, and laboratory characteristics of SCD.

Statistical analysis

Data collection involved using a questionnaire and data capture form, both without personal identifiers and accessible solely by authorized personnel. The collected data underwent coding before being entered into R Studio version 4.2.2 for subsequent analysis, with data completeness independently verified. Comparative analysis was conducted between HIV-positive and HIV-negative participants with and without SCD using χ^2 and *t*-tests. Continuous variables were summarized using mean, median, and standard deviation. Demographic data were presented using descriptive statistics, such as frequencies and percentages. Binary logistic regression analysis was employed for inferential statistics to describe the clinical and laboratory characteristics of individuals with SCD in the context of HIV and SCD comorbidity, evaluate the impact of HIV on SCD, and determine the correlation between HIV infection and various laboratory parameters (i.e., platelets, red blood cells, white blood cells, lactate dehydrogenase, and hemoglobin) in the context of SCD.

Ethical issues and approval

Ethical clearances were obtained from the University of Nairobi, Department of Pediatrics and Child Health, Homa Bay County Department of Health, and the management of Homa Bay County Teaching and Referral Hospital. Ethical approval was also granted by the Kenyatta National Hospital's Ethical Review Committee. Consent was obtained from parents and guardians of study patients, with informing participants on their rights, including option to withdraw from the study at any time. No monetary or material incentives were provided to participants, ensuring their involvement was driven by altruism and advancement of scientific understanding. Anonymity was maintained throughout the study by employing unique identification codes instead of personal identifiers. The collected data were securely stored in a locked cabinet within the researcher's office, with exclusive access granted to the researcher.

Results

Reliability and validity of the study

The measurement instrument exhibited robust reliability, with a Cronbach's α coefficient of 0.78, signifying strong internal consistency within the item set. Content validity analysis corroborated this result, revealing extensive consensus among the experts. Of the items assessed, approximately 86% were cleared as relevant and the remaining few were adjusted accordingly following the suggested comments.

Socio-demographic characteristics of the study population

The study arm involved 101 participants with SCD and HIV comorbidity, while the control arm comprised 102 SCD-only individuals. Baseline characteristics of children in the two groups, i.e., SCD and HIV and SCD without HIV are shown in Table 1.

Gender distribution among the respondents indicated a nearly equal representation, with males involving 50.2% and females accounting for 49.8% of the sample population. In terms of education, the majority of the participants (72.4%) had completed primary education, while 14.8% had secondary education, 4.4% had attended college, 2.5% had university-level education, and 5.9% reported education at other levels.

Age distribution revealed that respondents aged below 5 years constituted 27.6% of the study cohort, those aged 6 to 10 years accounted for 32.5%, those aged 11 to 15 years represented 27.6%, and individuals aged between 15 and 17 years included 12.3% of the total. Regarding occupation, the participants exhibited diverse categories, with 3.4% being students, 30% engaged in business activities, 23.6% working as farmers, 17.7% being formally employed, 12.8% being involved in casual labor, and 12.3% reporting no employment status. Furthermore, the study highlighted a substantial familial impact of SCD and HIV. A significant proportion of the respondents (82.8%) reported having at least one family member with SCD, and 24.6% had a family member with HIV. Remarkably, 14.3% of the participants reported having family members affected by both HIV and SCD. Family composition revealed that 73.9% of the patients had both parents, 19.2% had only one parent, 3.9% were orphans, and 2% lived with guardians.

Clinical, nutritional, and laboratory characteristics

Clinical, nutritional, and laboratory characteristics of the study participants are presented in Table 2.

Clinical data demonstrated that the odds for vaso-occlusion crisis among HIV-positive individuals was 0.26 (95% CI: 0.14-0.48, $p < 0.0001$), indicating a statistically significant association between vaso-occlusion and HIV-positive status with SCD. This implied that HIV-positive SCD patients were 74% likely to experience vaso-occlusion, as opposed to HIV-negative individuals. Infections among HIV-negative persons was 86% lower (OR = 0.14, 95% CI: 0.07-0.27) as compared with HIV-infected SCD patients; *p*-value was less than 0.0001, indicating a statistically significant relationship between infection and HIV-SCD comorbidity. Neuropathy

Table 1. Demographics characteristics of the study participants (*N* = 203)

Characteristic	HIV with SCD (*n* = 101)	HIV without SCD (*n* = 102)	OR (95% CI)	*p*-value
Children				
Age				
0-5 years	19	37	0.55 (0.26-1.14)	0.109
6-10 years	32	34		
11-15 years	32	24		
16-17 years	18	7		
Sex				
Male	50	52	0.94 (0.54-1.64)	0.84
Female	51	50		
Education				
Primary	71	76	0.93 (0.42-2.08)	0.87
Secondary	15	15		
College	4	5		
University	5	0		
Other	6	6		
Caregivers				
Income				
Jobless	14	25	1.09 (0.35-3.37)	0.88
Casual	14	12		
Employed	23	13		
Farmer	18	30		
Business	29	32		
Student	3	4		
Housing				
Both parents	72	78	0.88 (0.43-1.79)	0.72
One parent	20	19		
Orphan	5	3		
Living with guardian	4	2		

cases were found to be lower among HIV-negative patients (OR = 0.29, 95% CI: 0.16-0.52, $p < 0.0001$). When compared with HIV-infected cases, HIV-negative SCD patients were more likely to suffer less episodes of neuropathy and pain compared with HIV-positive SCD patients. Splenic sequestration (OR = 0.28, 95% CI: 0.15-0.49, $p < 0.0001$) was less likely to occur in HIV-negative SCD patients compared with HIV-positive SCD individuals.

Laboratory data showed that hematocrit level among HIV-negative persons was 53% higher (OR = 0.53, 95% CI: 0.30-0.95). At $p < 0.05$, this was statistically significant, suggesting that HIV-negative SCD patients were at a lower risk to suffer from anemia compared with HIV-infected SCD patients. MCV among HIV-positive individuals was statistically significant (OR = 0.2448, 95% CI: 0.1312-0.4453) at $p < 0.0001$. This indicated that MCV was positively correlated with HIV-positive status, with HIV-infected individuals having higher MCV values compared with HIV-negatives. Non-HIV-infected respondents' odds ratio for platelets was 0.2635, with a 95% CI ranging from 0.1370 to 0.4907; at $p < 0.0001$, a statistically significant association between platelets and the outcome for this group was found. This suggested that HIV-negative individuals were less likely to suffer bleeding disorders compared with HIV-positives. The mean neutrophil count among HIV-negative SCD participants was 0.22 (95% CI: 1.113-1.435; $p < 0.0001$). Compared with HIV-positive SCD participants, HIV-negative participants had significantly higher neutrophil counts.

Nutritional status assessment using weighing scale revealed that HIV-negative SCD patients were more likely to have normal weight (OR = 0.39, 95% CI: 2.34-8.42, $p < 0.0001$) than HIV-positive individuals.

Table 2. Clinical, nutritional, and laboratory characteristics of the study participants (*N* = 203)

Characteristic	HIV with SCD (*n* = 101)	HIV without SCD (*n* = 102)	OR (95% CI)	*p*-value
Clinical characteristics				
Vaso-occlusive crisis	79	49	0.26 (0.14-0.48)	< 0.0001
Infection	85	43	0.14 (0.07-0.27)	< 0.0001
Neuropathy	75	46	0.29 (0.16-0.52)	< 0.0001
Splenic sequestration	71	40	0.28 (0.15-0.49)	< 0.0001
Laboratory				
Hematocrit	72	58	0.53 (0.30-0.95)	0.03
MCV	78	46	0.24 (0.13-0.45)	< 0.0001
Platelets	82	54	0.26 (0.14-0.49)	< 0.0001
Neutrophils	75	37	0.22 (0.11-0.36)	< 0.0001
Nutrition				
Weight				
Underweight	57	27	0.39 (2.34-8.42)	< 0.0001
Normal	29	61		
Obese	15	14		

Discussion

The positive correlation between HIV and vaso-occlusion align with findings by Kato *et al.* [13], who demonstrated the influence of HIV on endothelial dysfunction and coagulation pathways, potentially increasing vaso-occlusive events in SCD patients with HIV co-infection [14]. Similarly, David *et al.* [15] reported elevated odds of infections among individuals with HIV-SCD comorbidity, indicating compromised immune function due to the interaction between these conditions [16]. The heightened likelihood of splenic sequestration among those with HIV-SCD comorbidity reflects HIV's potential impact on splenic function, exacerbating SCD-related complications [13].

The observed relationship between neuropathy and HIV-SCD confirms findings by Belisário *et al.* [17], highlighting neurological complications in individuals with co-existing HIV and SCD. The amplified pain experienced by individuals with HIV-SCD dual diagnosis [18] underscores the cumulative pain burden from these conditions, influenced by the interaction between HIV-associated inflammation and SCD-related pain mechanisms.

The positive correlation between neutrophil count and HIV status suggests that HIV infection affects immune responses in SCD individuals; this is in line with Cannas *et al.* [19], who demonstrated the complex interplay between HIV infection and immune dynamics. The association between platelet levels and outcomes for HIV-negative individuals aligns with Vishnu *et al.* [20], revealing connections between platelet activation, HIV infection, and inflammation. Similarly, MCV and HIV-positive status correlation among individuals with SCD might indicate hematological alterations related to HIV infection, as observed by Tomaiuolo [21]. The significant relationship between hematocrit and HIV-positive status in the context of SCD extends our understanding of hematological consequences, which is consistent with Dai *et al.* [22] exploration of hematocrit changes in response to HIV infection.

Our investigation into the relationship between HIV status, weight categories, and SCD, offers insights into the dynamics of weight distribution among intersecting groups. HIV-negative individuals had a considerably higher likelihood of having normal weight compared with HIV-SCD patients, highlighting the importance of adequate nutrition and body mass in influencing outcomes [23]. The non-significant effect indicating that HIV-negative individuals were 0.770 times less likely to be overweight than underweight individuals, might reflect multifactorial impacts on weight status [15].

Limitations of the study

The study was exclusively conducted at the Homa Bay County Teaching and Referral Hospital within Homa Bay County. Although conducting the research within this setting, potential challenges, such as missing data from hospital records, language barriers, and weather fluctuations, impacted data collection and participants' access to the facility. Nonetheless, rigorous measures were applied to mitigate these challenges, ensuring that participants provided accurate and comprehensive information.

Conclusions

This comprehensive study unveiled intricate relationships between HIV infection and SCD, spanning familial impact, clinical manifestations, laboratory parameters, and

weight status. The co-existence of these conditions within families emphasizes the need for integrated healthcare strategies. The observed correlations between clinical outcomes and laboratory measures highlight potential underlying mechanisms, contributing to a more subtle and complex understanding of their interaction. These findings resonate with prior research, extending our comprehension of the relationship between HIV and SCD. Ultimately, this study underscores the complexity of these interactions, emphasizing the importance of tailored interventions and holistic care for individuals affected by both HIV and SCD.

Disclosures

1. Institutional review board statement: Ethical clearances were obtained from the University of Nairobi, Department of Pediatrics and Child Health, Homa Bay County Department of Health, and the management of Homa Bay County Teaching and Referral Hospital. Ethical approval was also granted by the Kenyatta National Hospital's Ethical Review Committee.
2. Assistance with the article: We would like to acknowledge the US National Institutes of Health and University of Nairobi Health-Professional Partnership Initiative (HEPI), Kenya.
3. Financial support and sponsorship: This work was supported by funds from the US National Institutes of Health, grant No. R25TW011212, through the University of Nairobi Health-Professional Partnership Initiative (HEPI), Kenya.
4. Conflicts of interest: None.

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