

Journal of Clinical Oncology Reports

Research Article

Detection of Circulating Tumor Cells in Peripheral Blood as a Prognostic Indicator among Sudanese Breast Cancer Patients in Shendi, Sudan

Idris Mobarak I. Fadol¹, Abdalrhman Ali Alkhalifa Alhfyan¹, Abrar Ezaldin M. Alawad¹, Mohammed Abdelgader Elsheikh¹, Ibrahim B Elemam¹, Asma Al-Ameer M Zeen¹, Zeinab A Mohamed¹, Salwa Mohamed A. Elmahjob¹, Ayat Mustafa O. Mohamed¹, Tibyan Abd Almajed Altaher², Ghanem Mohammed Mahjaf^{3*}

¹Faculty of Medical Laboratory Science, Department of Histopathology, Shendi University, Shendi, Sudan.

²Faculty of Medical Laboratory Sciences, Department of Clinical Chemistry, Shendi University, Shendi, Sudan.

³Faculty of Medical Laboratory Sciences, Department of Medical Microbiology, Shendi University, Shendi, Sudan.

***Corresponding Author:** Ghanem Mohammed Mahjaf, Faculty of Medical Laboratory Sciences, Department of Medical Microbiology, Shendi University, Shendi, Sudan.

Received Date: 20 December 2025; **Accepted Date:** 16 January 2026; **Published Date:** 22 January 2026

Copyright: © 2026 Ghanem Mohammed Mahjaf, this is an open-access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Abstract

Background: Breast cancer is the most common malignancy among women worldwide and remains a major contributor to cancer-related morbidity and mortality. Circulating tumor cells (CTCs) have emerged as a promising liquid biopsy marker for prognostic assessment. However, data regarding CTC prevalence and clinical relevance among Sudanese breast cancer patients are limited.

Objective: To detect CTCs in the peripheral blood of Sudanese breast cancer patients and compare them with healthy controls, and to assess their association with clinicopathological characteristics.

Materials and Methods: A cross-sectional study was conducted in Shendi, Sudan, including 30 histologically confirmed breast cancer patients and 30 healthy controls. Buffy coat preparations were processed using 2% glacial acetic acid, followed by smear preparation and Giemsa staining. CTCs were identified microscopically based on morphological criteria. Statistical analysis was performed using chi-square tests.

Results: CTCs were detected in 11 of 30 breast cancer patients (36.6%), while none were found among the controls ($p < 0.001$). No significant associations were observed between CTC positivity and tumor type ($p = 0.367$), tumor stage ($p = 0.332$), or age group ($p = 0.209$), although higher CTC frequencies were noted in advanced stages and older patients.

Conclusion: CTCs are detectable using conventional Giemsa staining in a substantial proportion of Sudanese breast cancer patients and may serve as a potential non-invasive prognostic indicator. Larger studies using more sensitive detection methods are recommended to further clarify their clinical value.

Keywords: Breast cancer, Circulating tumor cells, CTCs, Giemsa stain, Prognostic marker, Sudan.

Introduction

Breast cancer is the most common malignancy among women worldwide and remains a major cause of cancer-related morbidity and mortality. According to the World Health Organization (WHO), breast cancer caused approximately

670,000 deaths globally in 2022 and is the most frequently diagnosed cancer in 157 out of 185 countries, occurring across both high- and low-income settings [1]. In Sudan, breast cancer represents a significant public health burden. Most cases are diagnosed at advanced stages, resulting in lower survival rates compared to high-income countries [2]. Local studies indicate that Sudanese patients are often younger at presentation and tend to have late-stage disease at diagnosis, largely due to socioeconomic barriers and limited healthcare access. This underscores an urgent need for reliable, accessible prognostic and monitoring biomarkers to improve patient management and outcomes [3,4]. In recent years, liquid biopsy has emerged as a promising non-invasive strategy for tumor evaluation. This approach involves analyzing blood-derived components such as circulating tumor cells (CTCs), cell-free DNA, and exosomes, offering real-time insights into tumor biology and dynamics. Such biomarkers are valuable for monitoring disease progression, assessing treatment response, and detecting relapse without the need for repeated invasive tissue biopsies [5]. Circulating tumor cells are malignant cells shed from primary or metastatic tumors into the bloodstream. They play a crucial role in metastasis through mechanisms such as epithelial-to-mesenchymal transition (EMT), immune evasion, and colonization of distant organs. The presence of CTCs in peripheral blood has been strongly associated with disease progression and poorer clinical outcomes in breast cancer patients [6]. Several methods have been developed to detect CTCs, including size-based filtration, immunomagnetic separation using epithelial markers (e.g., EpCAM), molecular assays, and conventional cytological stains such as Giemsa or Wright's stain. While advanced immunoassays and fluorescence-based techniques offer improved sensitivity and specificity, stains like Giemsa remain practical, accessible, and cost-effective—particularly in resource-limited laboratory settings [7]. Meta-analyses and clinical trials have established that CTC detection and enumeration correlate with overall survival and progression-free survival in breast cancer. Platforms such as CellSearch® have been approved for clinical CTC monitoring, reinforcing their prognostic and therapeutic relevance [8]. However, data from Sudan on the prognostic role of CTCs in breast cancer remain scarce. The absence of local studies correlating CTC presence or morphology with clinical outcomes represents a significant knowledge gap. Therefore, evaluating CTC detection using simple, affordable methods such as Giemsa staining may offer a feasible and locally applicable approach for clinical monitoring and prognostication among Sudanese breast cancer patients [9].

Materials and Methods

Study Design and Setting

A descriptive comparative cross-sectional study was con-

ducted to detect circulating tumor cells (CTCs) in peripheral blood as a prognostic marker among Sudanese breast cancer patients in Shendi City. The study was carried out at the Tumor Therapy and Cancer Research Center in Shendi from August to December 2025.

Study Population and Sampling

The study population comprised women diagnosed with breast cancer in Shendi. A total of sixty methanol-fixed blood smears (buffy coat preparations) were included: thirty from breast cancer patients (case group) and thirty from apparently healthy individuals (control group).

Inclusion Criteria

All women diagnosed with breast cancer who agreed to provide blood samples and attended the hospital during the study period were eligible.

Exclusion Criteria

Individuals with malignancies other than breast cancer were excluded from the study.

Sample Collection and Processing

Peripheral blood samples (6 mL) were collected in EDTA tubes and centrifuged at 1500 revolutions per minute (RPM). The buffy coat layer was carefully separated and mixed with 2% glacial acetic acid (GAA), followed by incubation for 5 minutes and recentrifugation. The resulting sediment was used to prepare smears on glass slides, which were then air-dried and fixed in methanol.

Detection of Circulating Tumor Cells

Slides were stained with Giemsa stain and examined under a light microscope using 10×/0.25 and 40×/0.65 objective lenses. CTCs were identified based on morphological criteria, including large nuclear size, irregular nuclear contours, prominent nucleoli, and high nuclear-to-cytoplasmic ratio. A sample was considered CTC-positive if tumor epithelial cells were clearly visualized in the buffy coat preparation.

Data Collection

Clinical and demographic data, including age, tumor stage, and histological type of breast cancer, were collected from participants using structured questionnaire sheets at the Tumor Therapy and Cancer Research Center.

Quality Control

Quality control measures were implemented at each stage of sample processing, staining, and microscopic examination to ensure the reliability and accuracy.

Data Analysis

Statistical analysis was performed using IBM SPSS version 26. Descriptive statistics were used to summarize participant characteristics. Associations between CTC presence and

clinicopathological variables were evaluated using Pearson's chi-square test. One-way ANOVA was applied where appropriate. A p-value < 0.05 was considered statistically significant.

Ethical Considerations

The study protocol was approved by the Department of Histopathology and Cytology in the College of Medical Laboratory Sciences at Shendi University and was reviewed by the institutional ethical review committee. Written informed consent was obtained from all participants after explaining the study aims, procedures, and confidentiality measures. All study procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (1964).

Results

A total of 60 peripheral blood smears were examined, including 30 from breast cancer patients and 30 from healthy controls. The baseline characteristics of both groups (Ta-

ble 1). Circulating tumor cells (CTCs) were detected in 11 of the breast cancer patients (36.6%), whereas none of the healthy controls showed any CTCs, yielding a statistically significant difference ($p < 0.001$) (Table 1). Regarding tumor histology, the majority of patients had invasive ductal carcinoma (IDC) (97.7%), while only one case was diagnosed as invasive lobular carcinoma (ILC). However, no significant association was found between tumor type and CTC positivity ($p = 0.367$) (Table 2). Analysis of tumor stage showed that CTC positivity was higher among stage III patients (7/14; 50%) compared to stage II (4/15; 26.7%) and stage I (0/1), although this difference did not reach statistical significance ($p = 0.332$) (Table 2). Similarly, no significant association was observed between CTC detection and age group ($p = 0.209$). However, CTCs were more frequently observed among patients older than 50 years (7/13; 53.8%) compared to younger age groups (Table 2). Overall, although significant correlations with clinicopathological variables were not established, CTCs were exclusively found among breast cancer patients and absent in all healthy controls.

Variable	Breast Cancer Patients (n=30)	Healthy Controls (n=30)
CTC Detection		
Positive	11 (36.6%)	0 (0%)
Negative	19 (63.4%)	30 (100%)
Tumor Type		
Invasive Ductal Carcinoma (IDC)	29 (97.7%)	–
Invasive Lobular Carcinoma (ILC)	1 (3.3%)	–
Tumor Stage		
Stage I	1 (3.3%)	–
Stage II	15 (50%)	–
Stage III	14 (46.7%)	–
Age Groups		
29–39 years	7 (23.3%)	–
40–50 years	10 (33.4%)	–
>50 years	13 (43.3%)	–

Table 1. Baseline Characteristics and CTC Detection Among Breast Cancer Patients and Controls

Variable	CTC-Positive (n=11)	CTC-Negative (n=19)	p-value
Tumor Type			0.367
IDC	10 (90.9%)	19 (100%)	
ILC	1 (9.1%)	0 (0%)	
Tumor Stage			0.332
Stage I	0 (0%)	1 (5.3%)	
Stage II	4 (36.4%)	11 (57.9%)	
Stage III	7 (63.6%)	7 (36.8%)	

Age Group			0.209
29–39 years	1 (9.1%)	6 (31.6%)	
40–50 years	3 (27.3%)	7 (36.8%)	
>50 years	7 (63.6%)	6 (31.6%)	

Table 2. Association Between CTC Detection and Clinicopathological Characteristics

Discussion

Breast cancer remains the most common malignancy among women globally and a leading cause of cancer-related morbidity and mortality. According to the World Health Organization, breast cancer was responsible for approximately 670,000 deaths worldwide in 2022 and is the most frequently diagnosed cancer in 157 out of 185 countries, affecting populations across high- and low-income settings alike [1]. This study aimed to determine the presence and clinical relevance of circulating tumor cells (CTCs) in Sudanese breast cancer patients. Our findings demonstrated that CTCs were detected in 11 out of 30 breast cancer patients (36.6%), whereas none were identified in the healthy control group, yielding a statistically significant difference ($p < 0.001$). These results align with the study by Hattori et al. (2019), which reported a higher detection rate of CTCs in breast cancer patients compared to healthy individuals [10]. This consistency supports the potential utility of CTCs as a reliable biomarker for distinguishing malignant from non-malignant conditions, particularly when using accessible detection methods such as Giemsa staining. About tumor histology, our analysis found no statistically significant association between CTC detection and breast cancer subtype ($p = 0.367$). Among CTC-positive cases, invasive ductal carcinoma (IDC) accounted for the majority (10/11), while only one case of invasive lobular carcinoma (ILC) was CTC-positive. This distribution contrasts with findings from Narbe et al. (2020), who reported a significantly higher frequency of CTCs in ILC compared to IDC [11]. This discrepancy may be attributable to the limited sample size of ILC cases in our cohort ($n=1$), underscoring the need for larger, subtype-stratified studies in the Sudanese population. Similarly, no significant correlation was observed between CTC positivity and tumor stage in our cohort ($p = 0.332$). Although a higher proportion of CTC-positive cases was observed in stage III (7/14) compared to stage II (4/15) and stage I (0/1), this trend did not reach statistical significance. These results differ from those of Thomas-Bonafos et al. (2024), who reported a strong association between CTC presence and advanced disease stage, particularly in metastatic settings [12]. Variations in sample collection protocols, smaller sample sizes, and differences in patient recruitment timelines may have influenced these outcomes. Furthermore, our analysis revealed no significant association between CTC detection and patient age ($p = 0.209$). This finding is consistent with the study by Zhou et al. (2022), which

reported no significant correlation between CTCs and age or menopausal status in breast cancer patients [13]. This suggests that CTC presence may be more closely linked to tumor biology rather than demographic factors. Limitations of this study include the relatively small sample size and the use of a conventional staining method, which may limit sensitivity compared to advanced molecular or immunocytochemical techniques. Future studies should address these limitations through larger, longitudinal cohorts and multimodal detection approaches.

Conclusion

Circulating tumor cells (CTCs) were detected in more than one-third of Sudanese breast cancer patients and were completely absent among healthy controls, underscoring their diagnostic value. Although no statistically significant associations were observed between CTC positivity and tumor type, stage, or age, higher detection rates were noted among patients with advanced disease and older age groups. These findings support the potential role of CTCs as an accessible, non-invasive biomarker for breast cancer monitoring in resource-limited settings. Further studies using larger cohorts and more sensitive detection methods are recommended to validate these results and clarify the prognostic significance of CTCs in Sudan.

Recommendations

This study recommends conducting future research with larger sample sizes and more sensitive detection methods to validate the role of circulating tumor cells (CTCs) in breast cancer prognosis. Integrating CTC assessment into routine clinical monitoring, particularly in resource-limited settings, may enhance early detection of disease progression. Additionally, adopting advanced cytological or molecular techniques can improve diagnostic accuracy and support better patient management.

Acknowledgments

The authors appreciate the ethical review committee, and thanks are also due to the Department of Histopathology at the Faculty of Medical Laboratory Sciences for providing the research facilities for this study.

Sources of funding

There was no specific grant for this research from any funding organization in the public, private, or nonprofit sectors

Conflict of interest

The authors have declared that no competing interests exist.

References

1. World Health Organization. Patient navigation for early detection, diagnosis and treatment of breast cancer: technical brief. *World Health Organization*, 2024.
2. Muddather, Hiba F., Moawia MA Elhassan, and Areeg Faggad. "Survival outcomes of breast cancer in sudanese women: a hospital-based study." *JCO global oncology* 7, no. 1 (2021): 324-332.
3. Awadelkarim, K. D., C. Arizzi, E. O. M. Elamin, H. M. A. Hamad, P. De Blasio, S. O. Mekki, I. Osman et al. "Pathological, clinical and prognostic characteristics of breast cancer in Central Sudan versus Northern Italy: implications for breast cancer in Africa." *Histopathology* 52, no. 4 (2008): 445-456.
4. Elhassan, Samah Isam Abdalla. "The five-year survival rate of breast cancer at Radiation and Isotopes Centre Khartoum, Sudan." *Heliyon* 6, no. 8 (2020).
5. Allen, Tyler A. "The role of circulating tumor cells as a liquid biopsy for cancer: advances, biology, technical challenges, and clinical relevance." *Cancers* 16, no. 7 (2024): 1377.
6. Han, Tuo, Juanjuan Zhang, Dong Xiao, Binhui Yang, Liang Chen, Chao Zhai, Feifei Ding, Yue Xu, Xiaoyu Zhao, and Jiangman Zhao. "Circulating Tumor-Derived Endothelial Cells: An Effective Biomarker for Breast Cancer Screening and Prognosis Prediction." *Journal of Oncology* 2022, no. 1 (2022): 5247423.
7. Ju, Siwei, Cong Chen, Jiahang Zhang, Lin Xu, Xun Zhang, Zhaoqing Li, Yongxia Chen, Jichun Zhou, Feiyang Ji, and Linbo Wang. "Detection of circulating tumor cells: opportunities and challenges." *Biomarker research* 10, no. 1 (2022): 58.
8. Bidard, François-Clément, Stefan Michiels, Sabine Riethdorf, Volkmar Mueller, Laura J. Esserman, Anthony Lucci, Bjørn Naume et al. "Circulating tumor cells in breast cancer patients treated by neoadjuvant chemotherapy: a meta-analysis." *JNCI: Journal of the National Cancer Institute* 110, no. 6 (2018): 560-567.
9. Ahmed, Ahmed Balla M., Salma Alrawa, Ahmed A. Yeddi, Esraa SA Alfadul, Hind Mohi Aldin Abd Allah, and Muhannad Bushra Masaad Ahmed. "Breast cancer burden in eastern Sudan: seven-year retrospective study." *ecancermedicalscience* 18 (2024): 1704.
10. Hattori, Masaya, Hayao Nakanishi, Mayumi Yoshimura, Madaoka Iwase, Akiyo Yoshimura, Yayoi Adachi, Naomi Gondo et al. "Circulating tumor cells detection in tumor draining vein of breast cancer patients." *Scientific reports* 9, no. 1 (2019): 18195.
11. Narbe, Ulrik, Pär-Ola Bendahl, Kristina Aaltonen, Mårten Fernö, Carina Forsare, Charlotte Levin Tykjær Jørgensen, Anna-Maria Larsson, and Lisa Ryden. "The distribution of circulating tumor cells is different in metastatic lobular compared to ductal carcinoma of the breast—long-term prognostic significance." *Cells* 9, no. 7 (2020): 1718.
12. Thomas-Bonafos, Thibault, Jean Yves Pierga, François-Clément Bidard, Luc Cabel, and Nicolas Kiavue. "Circulating tumor cells in breast cancer: clinical validity and utility." *NPJ Breast Cancer* 10, no. 1 (2024): 103.
13. Zhou, Min, Liping Jiang, Yiyi Fan, Tao Ma, Yan Wang, and Xu-zhen Wang. "Correlation between circulating tumor cells and different molecular biological characteristics in breast cancer patients." *Gland surgery* 11, no. 2 (2022): 466.

Citation: Ghanem Mohammed Mahjaf. et.al. Detection of Circulating Tumor Cells in Peripheral Blood as a Prognostic Indicator among Sudanese Breast Cancer Patients in Shendi, Sudan. *J. Clin. Oncol. Rep.* Vol. 5 Iss. 1. (2026) DOI: 10.58489/2836-5062/028