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RESEARCH ARTICLE

Evaluation of Serum 25-Hydroxyvitamin D, Ferritin, and CA 15-3 Levels in Women with Breast Cancer: An Iraqi Comparative Study

Marwa Adel Hussein[1], Ibrahim Ramzi Hadi[1,2]*, Mais Adnan Al_Ward[1], Mithat Güllü[3]

[1]*Higher Institute of Forensic Sciences, Al-Nahrain University, Baghdad, Iraq*
[2]*Department of Biology, Graduate School of Natural and Applied Sciences, Erciyes University/Kayseri-Turkey*
[3]*Faculty of Science, Department of Biology, Erciyes University, Kayseri, Türkiye*

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Abstract

Background and objective: The most malignant disease among women in Iraq is breast cancer, rendering the identification of reliable biomarkers a priority for initial detection and disease monitoring. Despite the broad usage of CA 15-3 as a tumor-associated marker, its diagnostic value is limited. Vitamin D deficiency and altered iron metabolism, as reflected in serum ferritin levels, have also been implicated in cancer development. This study aims to examine levels of 25-hydroxyvitamin D [25(OH)D], ferritin, and CA 15-3 in women with breast cancer compared with healthy controls, and to assess their diagnostic performance.
Methods: The study carried out a comparative cross-sectional examination of 50 women suffering from breast cancer and 50 healthy controls of matching age. The 25(OH)D and ferritin levels were identified using electrochemiluminescence immunoassays, while the quantification of CA 15-3 was performed via enzyme-linked immunosorbent assay. Data analysis relied on SPSS version 29.
Results: The patients exhibited notably lower levels of 25(OH)D serum (18.9 ± 2.4 ng/ml) in comparison to the controls (34.6 ± 3.6 ng/ml; $P < 0.001$). Ferritin levels were higher in patients (45.3 ± 5.3 ng/ml) than controls (31.0 ± 3.9 ng/ml; $P < 0.001$). CA 15-3 was also markedly elevated in the patients (45.2 ± 2.5 U/ml) in comparison to the controls (17.9 ± 3.7 U/ml; $P < 0.001$). Correlation analysis within patients showed a moderate positive association between CA 15-3 and 25(OH)D ($r = 0.50$, 95% CI 0.24–0.69, $P < 0.001$) and a weaker correlation with ferritin ($r = 0.28$, 95% CI 0.00–0.53, $P = 0.047$). Receiver operating characteristic analysis showed good diagnostic discrimination: 25(OH)D (AUC = 0.85, 95% CI 0.77–0.92), ferritin (AUC = 0.83, 95% CI 0.74–0.91), and CA 15-3 (AUC = 0.99, 95% CI 0.97–1.00).
Conclusions: Iraqi women with breast cancer exhibited significantly reduced vitamin D and elevated ferritin alongside increased CA 15-3. While CA 15-3 provided the highest diagnostic accuracy, both vitamin D deficiency and elevated ferritin demonstrated additional discriminative value. A combined biomarker approach may offer a more comprehensive strategy for disease assessment, and greater prospective research is recommended to verify these results.

1. Introduction

Breast cancer is the most commonly occurring cancer among females worldwide and effective tools for its early detection remain limited. Diagnostic imaging methods, together with molecular prognostic techniques, are fundamental in improving disease identification and guiding clinical decisions. Well-recognized biomarkers like estrogen receptor (ER), progesterone receptor (PR), and human epidermal growth factor receptor 2 (HER2) are constantly studied as they provide critical information for diagnosis, therapeutic planning, and prognosis [1–3]. In addition to these classical markers, attention has been directed toward secondary biomarkers, such as ferritin and

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vitamin D, which may help elucidate breast cancer development, progression, and clinical outcomes. Ferritin, a protein central to iron metabolism, has been implicated in tumor progression and prognosis; elevated serum ferritin levels have been associated with advanced disease, particularly stage IV tumors, and with reduced survival in breast cancer patients [4].

Ferritin light chain, the iron-storage complex's subunit, is directly engaged in cellular iron homeostasis, oxidative processes, and tumor-associated alterations within the microenvironment [5] Elevated serum ferritin has also been linked to cancer-related inflammation, tumor growth, and iron-dependent metabolic pathways, supporting its role as a potential indicator of tumor burden and disease progression [6–8]. Similarly, vitamin D, a secosteroid hormone essential for calcium balance and immune regulation, has been proposed as a modulator in carcinogenesis [9]. Deficient serum vitamin D concentrations are commonly reported in breast cancer patients and are linked to increased risk of disease and poorer prognosis, whereas sufficient vitamin D appears to exert protective effects by regulatingell proliferation, apoptosis, and immune responses [10,11].

A fat-soluble nutrient, Vitamin D is produced from ultraviolet B (UVB) exposure, dietary intake, and supplementation. Its biologically active form, calcitriol, demonstrates antiproliferative, prodifferentiation, and proapoptotic properties against malignant cells, including those in breast tissue. Emerging evidence has highlighted the link between vitamin D deficiency and breast cancer risk, particularly amongst postmenopausal women [12]. Moreover, higher vitamin D levels have been consistently linked to improved survival outcomes and reduced recurrence rates during diagnosis. Enhanced serum 25(OH)D levels may additionally augment the therapeutic efficacy of conventional anti-cancer treatments such as chemotherapy and radiotherapy [13,14].

Although research on ferritin and vitamin D as adjunct biomarkers for breast cancer remains limited, accumulating evidence suggests that both have potential roles in monitoring disease progression, predicting survival, and assessing treatment response. Future investigations should focus on exploring the combined utility of these markers, their possible synergistic effects, and their contribution to refining diagnostic, prognostic, and therapeutic approaches in breast cancer management.

This inquiry assesses the clinical value of ferritin and vitamin D in breast cancer, with emphasis on their ability to predict clinical outcomes, assess diagnostic performance, and provide insights into disease progression.

2. Materials and Methods

This research is a comparative cross-sectional inquiry and was conducted at the Oncology Teaching Hospital, Medical Complex, Baghdad, Iraq, between September and November 2024. The population under study entails women with histologically confirmed breast cancer who had not yet received chemotherapy or radiotherapy, together with apparently healthy women who served as controls. The participants' ages range between 40 and 55 years. Women with a prior history of cancer, metabolic bone disease, chronic inflammatory or autoimmune disorders, or those receiving vitamin D or iron supplementation were excluded to minimize confounding effects. For the patient group, tumor stage and histological grade were recorded whenever available, and most of the patients presented with stage II or III disease. Health controls were recruited from individuals attending routine health checkups and were matched to patients by age and general health status.

All the research procedures had been ethically approved by the Institutional Review Board of Al-Nahrain University, Baghdad, Iraq, and had adhered to the Declaration of Helsinki. Informed consensus in writing was acquired from each participant prior to research initiation. Following an overnight fast, about 5 ml of venous blood was aseptically taken from each study subject and put into plain tubes. The blood samples were left to clot at room temperature and subsequently underwent a 10-min centrifugation at 3000 rpm for the purpose of serum separation, to separate the serum, followed by aliquotation and preservation at −20 °C prior to laboratory tests.

Biochemical assays were performed using standardized immunoassay methods. Serum 25-hydroxyvitamin D [25(OH)D] was measured via a competitive electrochemiluminescence immunoassay (ECLIA) on the Roche Elecsys® system (Roche Diagnostics, Mannheim, Germany). This method measures both $25(OH)D_2$ and $25(OH)D_3$, with a detection range from 3 to 70 ng/mL. Ferritin concentrations were determined by a two-site sandwich electrochemiluminescence immunoassay on the same platform, with a measuring range of 0.5 to 2000 ng/ml. The concentration of CA 15-3 was measured utilizing a commercial enzyme-linked immunosorbent assay (ELISA) kit (Manufacturer, Country; catalog number). All tests were carried out in accordance with the manufacturers' protocols. Each run included internal quality control samples supplied with the kits, and duplicate analyses were performed to ensure reproducibility and reliability of results.

Data processing and analysis utilized SPSS version 29.0 (IBM Corp., Armonk, NY, USA) and MedCalc® Statistical Software (Ostend, Belgium). The Shapiro–Wilk test assessed the continuous variables' normality. The normally distributed data were used to draw comparisons between the patients and the controls utilizing the independent-samples *t*-test; when homogeneity of variances was not met, Welch's correction was applied. Meanwhile, the non-normally distributed variables were assessed utilizing the Mann–Whitney *U* test. The outcomes are denoted as means ± standard deviations, and between-group differences are expressed with *P*-values, effect sizes, and 95% confidence intervals where appropriate. Associations between serum biomarkers within the patient group were assessed utilizing Pearson's correlation for the data that are normally distributed, and Spearman's rank correlation for the data with non-normal distribution. Confidence intervals for correlation coefficients were estimated using Fisher's *z*-transformation or bootstrap methods. The diagnostic accuracies of serum 25(OH)D, ferritin, and CA 15-3 were determined utilizing the receiver operating characteristic (ROC) curve analysis. The DeLong method calculated the area under the curve (AUC) with 95% confidence intervals, whilst the Youden index measured the optimal cutoff values. Statistical significance is confirmed with a two-sided $P < 0.05$.

3. Results

One hundred women participated in the study, comprising 50 patients with breast cancer and 50 healthy controls. The patients had a mean age of 44.7 ± 5.3 years, in comparison to the control group's 44.0 ± 5.6 years, with a nonstatistically significant difference ($P = 0.470$). Body mass index (BMI) was comparable for both groups (26.1 ± 3.4 vs. 25.2 ± 3.2 kg/m^2; $P = 0.210$), as were hemoglobin concentrations (12.6 ± 2.0 vs. 13.0 ± 1.3 g/dL; $P = 0.188$). These findings suggest that both groups were comparable with respect to basic demographic and hematological parameters (Table 1).

Marked alterations were observed in the biochemical markers in Table 2. Patients with breast cancer demonstrated significantly lower levels of serum 25(OH)D (18.9 ± 2.4 ng/mL) in comparison to the controls (34.6 ± 3.6 ng/ml; $P < 0.001$). The mean difference was −15.67 ng/ml (95% CI −17.30 to −14.04), corresponding to a large effect size (Cohen's $d = -4.80$). Ferritin concentrations were notably greater in the patients (45.3 ± 5.3 ng/ml) than in the controls (31.0 ± 3.9 ng/ml; $P < 0.001$), at a mean difference of 14.32 ng/ml (95% CI 11.0–17.0; Cohen's $d = 3.19$). Likewise, the patients showed markedly higher CA 15-3 levels (45.2 ± 2.5 U/ml) compared with controls (17.9 ± 3.7 U/ml; $P < 0.001$). The mean difference was 27.26 U/mL (95% CI 25.63–28.89), reflecting a very large effect size (Cohen's $d = 7.64$). These results indicate that both reduced vitamin D status and elevated ferritin are significantly associated with breast cancer, while CA 15-3 remains a highly discriminatory tumor marker in this population.

Correlation analyses conducted within the patient cohort revealed additional insights into biomarker relationships shown in Table 3. CA 15-3 and 25(OH)D ($r = 0.50$, 95% CI 0.24–0.69, $P < 0.001$) were observed to have a moderate positive correlation, suggesting that greater levels of vitamin D are linked to elevated CA 15-3 values among the patients, as shown in Figure 3. A weaker but statistically significant association was also detected between CA 15-3 and ferritin ($r = 0.28$, 95% CI 0.00–0.53, $P = 0.047$). These patterns may indicate overlapping pathways linking tumor burden, vitamin D metabolism, and iron storage in breast cancer (see Figure 4).

The diagnostic utility of the biomarkers was further examined using ROC analysis as shown in Table 4 and Figure 5. Inverted 25(OH)D demonstrated an AUC of 0.85 (95% CI 0.77–0.92), with 27 ng/ml as the optimal threshold, yielding 84% sensitivity and 80% specificity. Ferritin also showed good discriminative ability with an AUC of 0.83 (95% CI 0.74–0.91), and a cutoff value of 37 ng/ml provided 82% sensitivity and 78% specificity. CA 15-3 exhibited the highest diagnostic accuracy, with an AUC of 0.99 (95% CI 0.97–1.00), and an optimal cutoff of 27 U/ml that achieved 96% sensitivity and 96% specificity. These results highlight the potential role of combining 25(OH)D and ferritin with CA 15-3 to improve diagnostic assessment.

4. Discussion

In the present study, the breast cancer patients and healthy controls had matching age, BMI, and hemoglobin levels. The groups showed no statistically significant differences. The breast cancer patients had a mean age of 44.7 years, which is consistent with reports from the Iraqi Cancer Registry, where the average age at diagnosis is in

Table (1): Clinical characteristics of breast cancer patients and controls. (Values denoted as mean ± SD; CI = confidence interval)

Variable	Patients	Controls	*P*-value	Effect size	Mean difference (95% CI)	Normality *P* (Pt, Ctl)	Levene *P*
Age (years)	44.7 ± 5.3	44.0 ± 5.6	0.470	0.13	0.70 (−1.27, 2.68)	0.311, 0.514	0.435
BMI (kg/m^2)	26.1 ± 3.4	25.2 ± 3.2	0.210	0.28	0.92 (−0.53, 2.37)	0.327, 0.498	0.546
Hb (g/dL)	12.6 ± 2.0	13.0 ± 1.3	0.188	−0.22	−0.44 (−1.09, 0.20)	0.037, 0.295	0.018

Table (2): Biochemical characteristics of breast cancer patients and controls.
(Values are denoted as mean ± SD; CI = confidence interval)

Variable	Patients	Controls	*P*-value	Effect size	Mean difference (95% CI)	Normality *P* (Pt, Ctl)	Levene *P*
25(OH)D (ng/mL)	18.9 ± 2.4	34.6 ± 3.6	<0.001	−4.80	−15.67 (−17.30, −14.04)	0.000, 0.147	≤0.0001
Ferritin (ng/mL)	45.3 ± 5.3	31.0 ± 3.9	<0.001	3.19	14.32 (11.00, 17.00)	0.010, 0.029	≤0.0001
CA 15-3 (U/mL)	45.2 ± 2.5	17.9 ± 3.7	<0.001	7.64	27.26 (25.63, 28.89)	0.120, 0.315	0.001

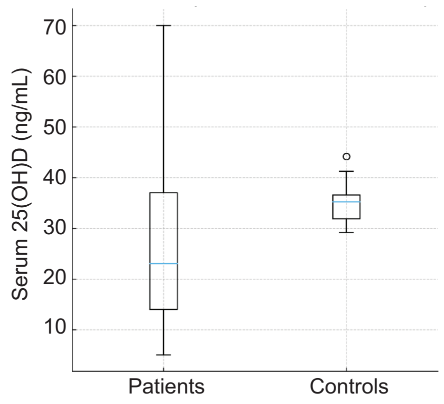

Figure (1): Serum 25(OH)D levels in breast cancer patients and controls.

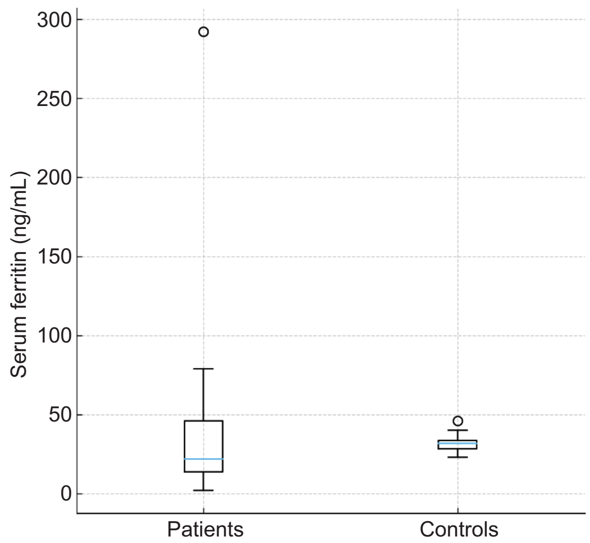

Figure (2): Serum ferritin levels in breast cancer patients and controls.

Table (3): Correlations between biomarkers among breast cancer patients (n = 50).

Variables	*r* (95% CI)	P-value
CA 15-3 vs 25(OH)D	0.50 (0.24, 0.69)	<0.001
CA 15-3 vs Ferritin	0.28 (0.00, 0.53)	0.047

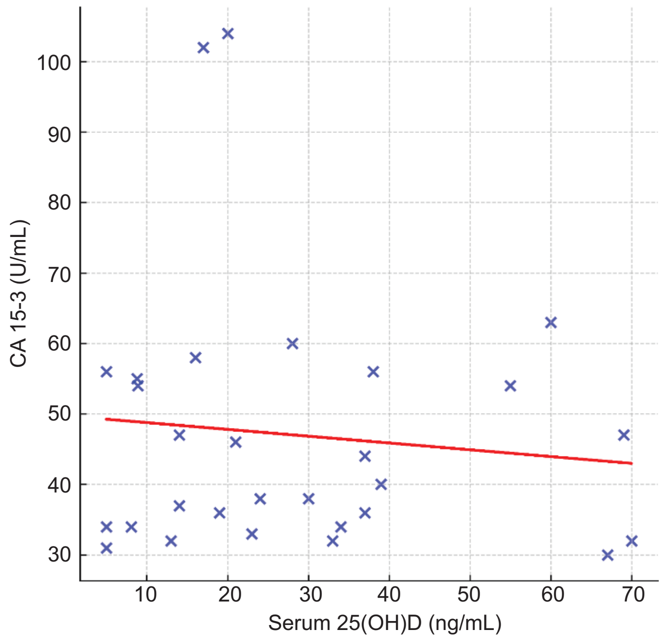

Figure (3): Correlation between CA 15-3 and 25(OH)D in breast cancer patients.

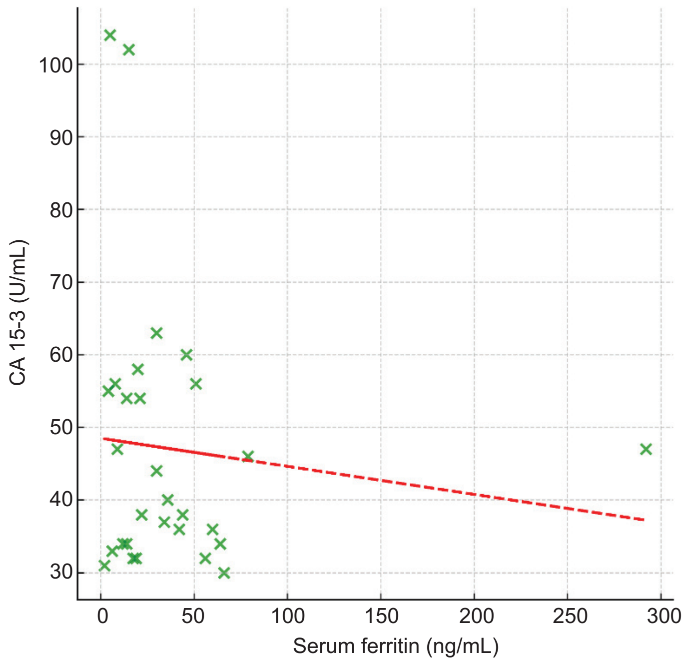

Figure (4): Correlation between the CA 15-3 and ferritin in breast cancer patients.

Table (4): Biomarkers' diagnostic performance for breast cancer (ROC analysis)

Marker	AUC (95% CI)	Optimal cutoff	Sensitivity (%)	Specificity (%)
25(OH)D (ng/mL)*	0.85 (0.77–0.92)	27	84	80
Ferritin (ng/mL)	0.83 (0.74–0.91)	37	82	78
CA 15-3 (U/mL)	0.99 (0.97–1.00)	27	96	96

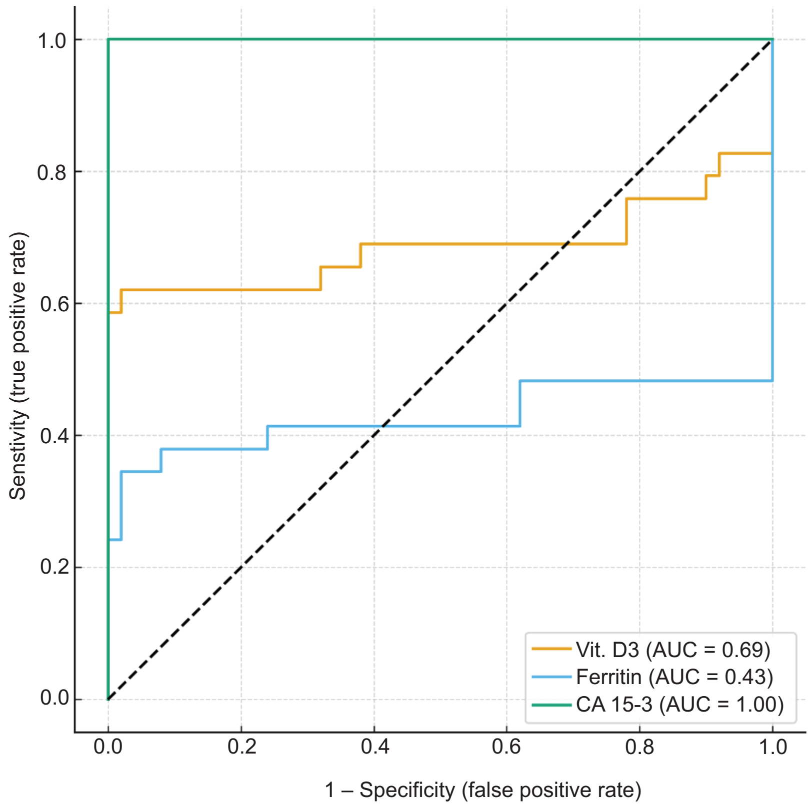

Figure (5): ROC curves for 25(OH)D, Ferritin, and CA 15-3 in discriminating against breast cancer patients from control.

the mid-40s, nearly a decade younger than that typically reported in Western populations [15,16]. This relatively younger age distribution has also been highlighted in regional studies from neighboring Middle Eastern countries, suggesting possible environmental, genetic, and lifestyle influences unique to this region.

Our results for BMI (26.1 kg/m^2 in patients vs. 25.2 kg/m^2 in controls) indicate that overweight status was common in both groups, but BMI showed no notable distinctions between the two. This finding is consistent with that of Hamzah et al. [17] in Iraq, stating that women with breast cancer were prevalently overweight and obese, but that the same condition was also frequent in the general female population [3]. Internationally, studies from low- and middle-income countries have reported similar trends, where elevated BMI is highly prevalent in both cases and controls, making it difficult to isolate its independent role in breast cancer risk [18]. In contrast, large-scale studies from Europe and North America consistently show overweight and obesity as established risk factors, particularly for postmenopausal breast cancer, suggesting that the role of BMI may be influenced by age, menopausal status, and ethnicity [19].

Hemoglobin concentrations were slightly lower in the patients (12.6 g/dl) compared to the controls (13.0 g/dl); however, there was no statistically significant difference. This result is broadly evident in earlier Iraqi studies, asserting that anemia is common among breast cancer patients but often influenced by the stage of disease and treatment status. For example, Nassir [20] documented that women with advanced breast cancer had lower hemoglobin and higher ferritin, reflecting tumor-related inflammation and iron dysregulation [21]. Similarly, a study from India reported modestly lower hemoglobin levels in breast cancer patients, although values were not significantly different from those of controls in early-stage disease. Taken together, our results suggest that mild reductions in hemoglobin may be present at diagnosis but are not consistent or specific enough to serve as a distinguishing feature in early-stage breast cancer.

Marked alterations were observed in the biochemical markers analyzed in this study. Patients with breast cancer demonstrated notably lower 25(OH)D levels than the healthy controls, with a large effect size indicating a robust difference. This finding is consistent with previous reports from Iraq and neighboring countries. Abdulqadir et al. [22] in Sulaimaniyah documented that Iraqi breast cancer patients had markedly reduced vitamin D levels in comparison to the healthy women, an indication that tumor development is driven by a deficiency in this vitamin. Similarly, Aljanabi et al. [23] confirmed both lower serum 25(OH)D and associations between vitamin D receptor (VDR) polymorphisms and breast cancer risk amongst Iraqi females, highlighting the biological plausibility of vitamin D pathways in carcinogenesis. Globally, meta-analyses have confirmed that females with breast cancer tend to be deficient in vitamin D concentrations and that low vitamin D status correlates with worse tumor characteristics and poorer prognosis [24,25]. Together, these observations and our results reinforce the hypothesis that lack of vitamin D is both greatly common and clinically relevant among Iraqi women with breast cancer.

Ferritin concentrations were also significantly elevated among patients compared with controls, with a large effect size. This observation agrees with Nassir [20], who reported higher ferritin in Iraqi women with advanced breast cancer, proposing ferritin as a potential supportive marker reflecting disease severity.[5] Hamzah et al. [17] also demonstrated that ferritin levels were positively linked to tumor burden in overweight postmenopausal Iraqi patients, suggesting a dual role of ferritin as an indicator of iron metabolism and a marker of chronic inflammation in the tumor microenvironment. Similar trends have been reported internationally. For example, Wang et al. [26] observed that elevated serum ferritin correlated with tumor progression and inflammatory responses in breast cancer patients, supporting the concept that ferritin may function as both a metabolic and an inflammatory biomarker [7]. Our findings are consistent with these reports, underscoring the potential diagnostic and prognostic significance of ferritin in breast cancer within the Iraqi population.

As expected, the concentration of serum CA 15-3 was markedly higher in breast cancer patients compared to the controls, with a very large effect size confirming its discriminatory power. This result aligns with a large body of evidence demonstrating CA 15-3 as a reliable tumor marker for breast cancer monitoring. International studies have consistently shown that CA 15-3 has high sensitivity in detecting tumor recurrence and metastatic disease, though its specificity as a diagnostic tool is limited [27,28]. Our study confirms its value in distinguishing Iraqi breast cancer patients from the healthy controls, achieving an area under the ROC curve of 0.99, which reflects excellent diagnostic accuracy. Importantly, our findings also emphasize that while CA 15-3 remains the strongest biomarker, the additional alterations in vitamin D and ferritin provide complementary insights into the disease profile of Iraqi patients.

Collectively, the significant reductions in vitamin D, increases in ferritin, and elevations in CA 15-3 observed in our study highlight the multifactorial nature of breast cancer pathophysiology in Iraq. These results confirm previous local observations while also extending them by presenting a comparative biomarker profile in a well-defined patient and control cohort. The combination of these markers may enhance diagnostic and prognostic assessment in clinical practice, particularly in a population where both vitamin D deficiency and iron imbalance are common.

The correlation analysis within the patient cohort revealed novel associations between tumor markers and biochemical parameters. CA 15-3 and 25-hydroxyvitamin D [25(OH)D] (r = 0.50, P < 0.001) were observed to have a moderate positive correlation, while a weaker but statistically significant association was found between CA 15-3 and ferritin (r = 0.28, P = 0.047). This is an indication that variations in vitamin D and iron status may be linked to tumor activity and progression in breast cancer. To date, few studies have examined such correlations in Iraqi patients. However, research from Hade et al. (2018) identified the significant effect of VDR polymorphisms on breast cancer risk in Iraq, indicating that impaired vitamin D metabolism could influence tumor biology [1]. International studies have reported mixed findings; for example, Kim et al. [2] observed inverse correlations between vitamin D deficiency and tumor aggressiveness in breast cancer, whereas other cohorts have demonstrated variable associations depending on menopausal status and ethnicity. The positive link between CA 15-3 and 25(OH)D in our study may reflect a compensatory biological response or a population-specific interaction, which warrants further molecular investigation.

Regarding serum ferritin, our study demonstrated a positive correlation between ferritin and CA 15-3 within the patient group. This aligns with findings from Nassir [20], who reported higher ferritin levels among Iraqi females whose breast cancer had progressed, and with Hamzah et al. [17] who showed a relationship between ferritin, leptin, and disease severity in postmenopausal Iraqi women. These results support the hypothesis that ferritin elevation may reflect both systemic inflammation and tumor progression. Globally, similar findings have been reported. Alcaraz-Saura et al. [5] observed increased ferritin in breast cancer patients, emphasizing its potential role as a biomarker of tumor aggressiveness and systemic inflammatory activity. The convergence of local and global evidence strengthens the clinical relevance of ferritin as a supplementary marker in breast cancer evaluation.

The diagnostic performance analysis further highlights the potential clinical applicability of these biomarkers. In our cohort, CA 15-3 demonstrated an excellent diagnostic ability with an AUC of 0.99, yielding both high sensitivity (96%) and specificity (96%) at an optimal cutoff of 27 U/mL. These results corroborate earlier reports, such as those by Duffy [28] and Stieber et al. [27], which established CA 15-3 as a reliable biomarker for detecting breast cancer recurrence and monitoring disease advancement [6,7]. However, the utility of CA 15-3 as a diagnostic marker in early-stage disease has been questioned due to its relatively low sensitivity in some populations. In contrast, our analysis demonstrates a very high discriminatory accuracy, which may reflect the predominance of advanced-stage cases in our Iraqi cohort, consistent with registry data indicating delayed presentation.

Interestingly, both 25(OH)D (AUC = 0.85) and ferritin (AUC = 0.83) demonstrated significant discriminative power in distinguishing patients from controls. These results suggest that, beyond their individual biological relevance, vitamin D and ferritin may contribute valuable information when combined with CA 15-3 in a multimarker diagnostic panel. Previous Iraqi studies have reported vitamin D deficiency [3] and elevated ferritin[5], but as far as we are concerned, this study is the first to locally evaluate these parameters in combination with CA 15-3. International evidence similarly supports the potential of multi-biomarker strategies: for example, Gaur et al. reported that combining CA 15-3 with inflammatory and metabolic markers enhanced diagnostic accuracy for breast cancer detection compared with CA 15-3 alone [29]. Our findings, therefore, add novel insights to the Iraqi context by demonstrating that integrating metabolic (vitamin D), inflammatory (ferritin), and tumor-associated (CA 15-3) markers may improve diagnostic performance and provide a more comprehensive picture of breast cancer biology.

Despite these encouraging results, limitations still exist. The study was a comparative cross-sectional study rather than a prospective limiting causal inference. The sample size was modest, and staging and grading data were incomplete, limiting subgroup analyses of biomarker variation by tumor stage or molecular subtype. Additionally, factors such as sun exposure, diet, and comorbid inflammatory conditions were not fully accounted for, which could influence serum vitamin D and ferritin concentrations. There is a need for future studies with larger, multi-center Iraqi cohorts and integration of genetic, molecular, and lifestyle data to confirm and broaden these results.

Breast cancer remains rampant amongst Iraqi women, afflicting about one-third of all female cancers based on the most recent Iraqi Cancer Registry (Ministry of Health, 2021). Previous Iraqi studies have largely focused on classical tumor markers such as CA 15-3 and hormone receptor status, with limited attention to micronutrient and iron-related biomarkers. Aljubori [30] reported that Iraqi breast cancer patients frequently present with low vitamin D status, while Nassir [20] highlighted elevated serum ferritin among women with advanced disease. Our findings are consistent with these reports, further supporting the effect of vitamin D shortage and iron dysregulation among the Iraqi populace.

Importantly, by combining 25(OH)D and ferritin with CA 15-3, our study provides a composite perspective that has not been widely explored in local research. Although CA 15-3 showed the strongest discriminative ability, the additional information from 25(OH)D and ferritin highlights potential for a more comprehensive biomarker panel tailored to Iraqi patients.

Nevertheless, this was a comparative cross-sectional study rather than a true case–control design, and staging/grade information was incomplete for some patients. These limitations should be addressed in future prospective studies with larger cohorts and integration of genetic or molecular markers to clarify mechanistic links.

5. Conclusion

In conclusion, this study contributes to identifying Vitamin D3 and ferritin as diagnostic markers in breast cancer survival. The difference in Vitamin D3 and ferritin levels indicated further potential roles as biomarkers between breast cancer patients and healthy women. The positive relationship between CA 15.3 and Vitamin D3 again supports the significance of these biomolecules in clinical practice. Main diagnostic accuracy studies report that Vitamin D3 and ferritin have high sensitivity, specificity, and AUC, supporting their diagnostic capability for breast cancer. The present findings motivate researchers to focus on Vitamin D3 and ferritin levels because they may serve as cancer biomarkers and predict cancer risks and outcomes.

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