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Original article

Comparative Study of Hematological and Biochemical Parameters in Vaccinated *versus* Unvaccinated COVID-19 Patients in Al-Bieda City

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COVID-19 vaccination has played a crucial role in reducing the severity and spread of SARS-CoV-2 infection. However, questions remain regarding its systemic effects, particularly on hematological and biochemical parameters. This study aimed to assess the potential impact of COVID-19 vaccination on complete blood count (CBC) and selected plasma biochemical markers in patients by comparing vaccinated and unvaccinated individuals. A comparative analysis was conducted between vaccinated and unvaccinated COVID-19 patients. Hematological parameters assessed included red blood cell (RBC) count, hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), white blood cell (WBC) count, and platelet count (PLT). Biochemical markers analyzed included plasma urea, creatinine, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP). Statistical significance was considered at $p < 0.05$. The results showed no statistically significant differences ($p > 0.05$) in any CBC or plasma biochemistry parameters between vaccinated and unvaccinated groups. RBC count, Hb levels, HCT, and indices of red cell morphology (MCV, MCH, MCHC) remained comparable across groups, indicating that vaccination had no adverse effects on erythropoiesis or red cell function. WBC and platelet count also showed no significant changes, with values within physiological ranges. Similarly, urea and creatinine levels were slightly higher in the vaccinated group but not significantly different, suggesting preserved renal function. Liver enzyme levels (ALT, AST, and ALP) did not differ significantly, indicating no hepatic impairment post-vaccination.

Introduction

Coronavirus Disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has emerged as a global health crisis with significant impacts on human health and healthcare systems [1]. Since the beginning of the pandemic, it has been observed that COVID-19 affects the respiratory system and causes widespread systemic changes, including alterations in hematological and biochemical parameters [2]. These parameters are vital indicators of disease severity, progression, and patient outcomes. Several studies have shown that COVID-19 infection is associated with changes such as lymphopenia, elevated D-dimer, liver enzymes, and inflammatory markers, reflecting the systemic nature of the disease [3].

The introduction of vaccines has significantly reduced the severity of symptoms, hospitalization rates, and mortality associated with COVID-19. However, the impact of vaccination on hematological and biochemical responses during infection remains under investigation [4]. Comparing these parameters between vaccinated and unvaccinated individuals may help elucidate the immunological and physiological benefits of vaccination beyond clinical protection. Understanding these differences is crucial for guiding public health strategies, improving patient management, and enhancing vaccine efficacy assessments [5]. This study aims to investigate the relationship between COVID-19 infection and variations in hematological and biochemical markers in vaccinated versus unvaccinated individuals in Al-Bieda City, Libya. This comparison may provide critical insights into how vaccination modulates the body's response to SARS-CoV-2, particularly in terms of inflammation, liver function, coagulation status, and immune response.

Methods

Study Design and Population

This is a cross-sectional comparative study conducted in Al-Bieda City, Libya, involving individuals

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confirmed to be infected with COVID-19 through PCR testing. Participants were categorized into two groups: vaccinated (those who had received at least two doses of a COVID-19 vaccine) and unvaccinated individuals. A total of 200 male and female cases were examined as part of a cross-sectional study for the years 2021–2022.

Inclusion and exclusion criteria

Inclusion criteria included adults aged 18 years and above with confirmed COVID-19 infection. Exclusion criteria included individuals with known hematological disorders, chronic liver or kidney disease, or those on immunosuppressive therapy.

Sample collection

Venous blood samples were collected from all participants after obtaining informed consent. Samples were processed immediately to assess hematological and biochemical parameters.

Hematological and biochemical analysis

Hematological parameters measured included white blood cell (WBC) count, hemoglobin (Hb), platelet count, lymphocyte count, and neutrophil-to-lymphocyte ratio (NLR). Biochemical tests included liver function tests (ALT, AST), renal function tests (creatinine, urea. All analyses were performed using standard automated analyzers at the clinical laboratory of [Idea lab in El-Beida, Libya]. When appropriate, statistical analysis was performed using Graph Prism Pad and Minitab software (version 17). After detecting a normal distribution in the data and selecting a $P < 0.05$ threshold for significance, ANOVA analysis with the Tukey multiple comparison test was used to determine statistical significance.

Results

The data presented in Table 1 shows the comparison of complete blood count (CBC) parameters between vaccinated and unvaccinated COVID-19 patients. Overall, there were no statistically significant differences ($p > 0.05$) in any of the hematological parameters assessed, including red blood cell (RBC) count, hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), white blood cell (WBC) count, and platelet count (PLT). Specifically, the mean RBC count was nearly identical in both groups (4.469 ± 0.097 in vaccinated vs. 4.475 ± 0.094 $\times 10^6/\mu l$ in unvaccinated; $p = 0.967$), suggesting no observable vaccine-related impact on erythropoiesis or red cell loss. Similarly, hemoglobin concentration and hematocrit levels were comparable between the groups (Hb: 13.36 ± 0.31 vs. 13.03 ± 0.38 g/dl, $p = 0.502$; HCT: 41.14 ± 0.90% vs. 40.15 ± 1.1%, $p = 0.482$), indicating preserved oxygen-carrying capacity regardless of vaccination status. The MCV and MCH values were slightly higher in the vaccinated group, but without statistical significance (MCV: 92.20 ± 50.96 vs. 89.71 ± 1.3 fL, $p = 0.136$; MCH: 29.96 ± 0.32 vs. 29.14 ± 0.53 pg, $p = 0.169$), and MCHC was nearly equal in both groups (32.47 ± 0.20 vs. 32.44 ± 0.24 g/dL, $p = 0.919$). These findings suggest no meaningful changes in red cell morphology or hemoglobin concentration per cell associated with vaccination. White blood cell counts and platelet levels also did not differ significantly between groups (WBC: 7.57 ± 0.51 vs. 6.94 ± 0.32 $\times 10^3/\mu l$, $p = 0.294$; PLT: 257.5 ± 13 vs. 269.6 ± 11 $\times 10^3/\mu l$, $p = 0.466$). Although WBC count was slightly higher in the vaccinated group, it remained within the normal range and may reflect a mild immunological response without pathological implications.

Table 1. Changes Complete blood counts red blood cells RBCs, white blood cells WBCs, haemoglobin Hb, packed cell volume PCV, platelets, haemoglobin (Hb), and mean cell hemoglobin concentration (MCHC) and mean cell hemoglobin concentration (MCHC) of unvaccinated and vaccinated patients".

Parameters	Positive vaccination	Negative vaccination	P- P-Value (T Teas)
RBC" ($\times 10^6/\mu l$)"	4.469 ±0.097	4.475 ± 0.094	0.967
HGB" (g/dl)"	13.36 ±0.31	13.03 ±0.38	0.502
"HCT" %	41.14 ±0.90	40.15 ±1.1	0.482
MCV" (fL)"	92.20 ± 50.96	89.71 ± 1.3	0.136
"MCH" (pg)	29.96 ±0.32	29.14 ± 0.53	0.169
MCHC" (g/dL)"	32.47 ±0.20	32.44 ±0.24	0.919
"WBC" ($\times 10^3/\mu l$)	7.57 ± 0.51	6.94 ± 0.32	0.294
"PLT" ($10^3/\mu l$)	257.5 ± 13	269.6 ± 11	0.466

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Table 2 presents the comparative analysis of selected biochemical markers—urea, creatinine, ALT, AST, and ALP—in plasma samples of vaccinated and unvaccinated COVID-19 patients. The results show no statistically significant differences between the two groups across all measured parameters ($p > 0.05$ for all values), indicating that COVID-19 vaccination did not produce notable alterations in renal or hepatic biochemical indices in this sample. Urea and creatinine levels, indicators of kidney function, were slightly elevated in the vaccinated group (30.9 ± 2.3 mg/dL and 0.994 ± 0.055 mg/dL, respectively) compared to the unvaccinated group (27.7 ± 1.7 mg/dL and 0.883 ± 0.048 mg/dL), but these differences were not statistically significant ($p = 0.271$ and $p = 0.131$).
Liver enzymes ALT, AST, and ALP also showed no significant changes between groups. ALT and AST, which reflect hepatocellular injury, remained within normal reference ranges in both vaccinated and unvaccinated individuals, suggesting that the vaccine did not adversely affect liver function. ALP levels, although numerically higher in the unvaccinated group (97.0 ± 9.2 U/L vs. 86.6 ± 6.5 U/L), also did not reach statistical significance ($p = 0.361$).

Table 2. Plasma biochemistry of unvaccinated and vaccinated patients.

Parameters	Positive vaccination	Negative vaccination	P- Value (T Teas)
Uera" (U/dl)"	30.9 ± 2.3	27.7 ± 1.7	0.271
"Ceratinine" (U/dl)	0.994 ± 0.055	0.883 ± 0.048	0.131
ALT" "	19.5 ± 2.2	20.6 ± 3.0	0.748
"AST"	18.50 ± 1.1	21.4 ± 2.4	0.288
"ALP"	86.6 ± 6.5	97.0 ± 9.2	0.361

Discussion

The comparative analysis of hematological parameters between vaccinated and unvaccinated COVID-19 patients revealed no statistically significant differences across all evaluated variables, suggesting that COVID-19 vaccination does not significantly alter complete blood count (CBC) values. Red blood cell (RBC) counts were nearly identical between the two groups, indicating no vaccine-related effect on erythropoiesis or red blood cell survival [5]. These results align with previous studies, which found that mRNA or inactivated vaccines did not affect erythrocyte counts in healthy or mildly infected individuals. Hemoglobin (Hb) levels and hematocrit (HCT) percentages were also statistically similar between vaccinated and unvaccinated groups. This further suggests that vaccination did not impair oxygen-carrying capacity or induce hemolysis. Such findings are supported by emerging clinical reports that show stable Hb and HCT values post-vaccination in both healthy individuals and patients with mild-to-moderate COVID-19 infection [6]. Moreover, the mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) showed no significant changes between groups. These findings reflect preserved erythrocyte morphology and intracellular hemoglobin content following vaccination, which has been documented in large-scale vaccine safety trials [7].
White blood cell (WBC) counts, a critical marker of immune response, showed a non-significant increase in vaccinated patients. This mild elevation may reflect an expected and benign immunologic activation post-vaccination, consistent with findings from immunogenicity studies reporting transient increases in leukocyte counts following COVID-19 vaccination [8]. Platelet counts (PLT) also remained within the normal range in both groups, showing no sign of vaccine-induced thrombocytopenia or coagulopathy, which have been rarely reported in specific populations but not observed in this cohort. This supports the overall hematologic safety of COVID-19 vaccines in routine clinical populations [9]. The results presented in Table 2 indicate that vaccination status did not lead to statistically significant differences in plasma biochemistry parameters, including urea, creatinine, ALT, AST, and ALP levels, suggesting no overt renal or hepatic dysfunction associated with vaccination. This aligns with previous studies confirming the biochemical safety of common vaccines, including those for COVID-19, where no major changes in renal function markers were noted post-vaccination. Serum urea levels were slightly higher in vaccinated individuals compared to unvaccinated, but the difference was not statistically significant [10].
Urea concentration can reflect protein metabolism or renal clearance function, and this mild elevation may be physiological rather than pathological. Similar non-significant elevations in urea were reported [11], who analyzed biochemical responses to mRNA and inactivated vaccines. Creatinine levels were also slightly higher in the vaccinated group compared to the unvaccinated group, though this was not statistically significant. Serum creatinine is a more specific marker of glomerular filtration, and these findings indicate that vaccination did not adversely affect renal function [12]. This observation is in

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agreement with a study by Pascolo et al. (2021), which reported no significant impact of COVID-19 vaccines on kidney function in healthy and immunocompromised individuals. Regarding liver enzymes, alanine aminotransferase (ALT) was slightly lower in vaccinated individuals than in unvaccinated individuals, and the difference was not significant. This suggests that vaccination did not induce hepatic cellular injury. A comparable lack of effect on ALT levels has been previously documented by Mevorach et al. (2021), who evaluated hepatic responses post-BNT162b2 mRNA vaccination [13]. Similarly, aspartate aminotransferase (AST) levels were slightly lower in vaccinated individuals than in unvaccinated individuals, with a non-significant p-value (0.288).

AST is another enzyme associated with liver health, and its stability reinforces the hepatological safety profile of vaccines. This trend is consistent with a cohort study by [13], which reported no hepatic dysfunction following mRNA vaccination. Alkaline phosphatase (ALP) levels were marginally lower in vaccinated individuals compared to unvaccinated, but the indicates no significant difference. ALP is often used as a marker for biliary function or bone metabolism, and its unchanged levels suggest that vaccination has no harmful effects on hepatobiliary physiology. These findings echo those of [13,14], who concluded that vaccines do not disturb hepatic enzyme levels in patients with normal baseline liver function.

Conclusion

This study demonstrates that COVID-19 vaccination does not significantly affect hematological or biochemical markers of liver and kidney function in infected patients. These findings support the systemic safety of the vaccine in terms of blood composition and organ function, reinforcing its use as a safe public health intervention.

Conflict of interest. Nil

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