Evaluating the Reliability of Coagulation Tests in Guiding Surgical Decisions for Spinal Interventions in Post-COVID-19 Patients

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Abstract

Background: The COVID-19 pandemic has introduced challenges in medical practices, impacting laboratory testing and raising concerns about the reliability of specific tests. This study aimed to assess the reliability of using hematology test results to delay surgeries, particularly in spinal interventions.

Methods: A retrospective analysis was conducted on the medical records of 220 patients who had undergone spinal surgery between October 2021 and June 2023, and whose COVID-19 status was documented. Inclusion criteria encompassed individuals without a history of blood disorders, pregnancy, drug or smoking addiction, or recent surgical procedures. Data analysis utilized SPSS software, employing descriptive methods and statistical tests such as the independent samples t-test and chi-square test, with statistical significance set at $p < 0.05$.

Results: Among the analyzed patients, 56.4% were male. Fusion surgery was performed on 82.7% of individuals, while laminectomy surgery was performed on 17.3%. Approximately 65.9% had no underlying conditions, and 67.3% had a history of prior COVID-19 infection. Postoperative thrombotic complications were observed in 2.2%. Comparisons between patients with and without coagulation complications revealed no significant differences in demographic information, history of COVID-19 infection, or coagulation test results. Furthermore, a comparison of D-dimer test outcomes between individuals with normal D-dimer levels [54 people] and those with levels exceeding 500 [55 people] demonstrated no significant distinction ($p > 0.05$).

Conclusions: Based on the findings, this study concludes that, for major and extensive spinal surgeries in patients with a history of COVID-19, evaluating D-dimer test results does not offer significant assistance in decision-making.

Keywords: Spinal surgery, COVID-19, Coagulation test, Coagulation complications, D-Dimer

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Introduction

Coronavirus disease 2019 (COVID-19), also known as the novel coronavirus, is an emerging disease that originated in Wuhan, China, in December 2019 and has since affected a significant number of individuals worldwide [1]. This virus belongs to the Coronavirus family, following the severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) viruses, and it has a high transmissibility rate from person to person [2]. On March 11, 2020, the World Health Organization (WHO) declared COVID-19 as a novel pandemic [3]. As of May 5, 2023, it is no longer in a state of emergency. However, residual effects of the disease can still impact community well-being and health.

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COVID-19 presents symptoms such as fever, cough, muscle fatigue, dyspnea, headache, and sore throat [4,6]. It can manifest as severe conditions such as organ failure, respiratory distress, pulmonary edema, and pneumonia in some individuals [5]. Furthermore, various studies conducted on COVID-19 patients have shown that this virus has extensive effects on different clinical aspects of individuals and induces alterations in the normal functioning of various systems. It has been observed that many individuals experience kidney and liver damage, nervous system disorders, and cardiovascular complications [7]. Another essential part of the body affected by this disease, with potential implications for patients' health status, is the circulatory system and the condition of blood cells [8].

Studies have shown that factors such as blood cell counts, lactate dehydrogenase levels, troponin, fibrinogen, C-reactive protein (CRP), prothrombin time (PT), partial thromboplastin time (PTT), and D-dimer are affected concurrently with COVID-19 infection [9,10]. In a study conducted by Khoshrang et al. [9], an increase in lactate dehydrogenase levels, elevated erythrocyte sedimentation rate (ESR), decreased lymphocytes, and increased neutrophils were observed through paraclinical tests in COVID-19 patients. Another study reported that various degrees of coagulation disorders occur following COVID-19 infection [11], and post-mortem results of individuals who died from COVID-19 confirmed the presence of thrombosis in the lungs, heart, and liver. According to reports, 25% of patients with severe COVID-19 have experienced venous thromboembolism (VTE) and pulmonary embolism (PE) [12]. Different studies conducted during COVID-19 infection have confirmed its impact on coagulation factors concurrent with the presence of symptoms. On the other hand, some studies have indicated that even after clinical improvement of the disease, certain changes such as persistently elevated D-dimer levels require medication for control and normalization [13]. However, other coagulation tests such as PT, PTT, and levels of coagulation factors like fibrinogen return to their pre-COVID-19 natural state [14].

Considering the global spread of COVID-19 in recent years and its long-term effects on individuals' health—particularly the results of hematological tests—and the importance of evaluating these tests before spinal surgeries to prevent postoperative complications, this study aims to determine the relationship between preoperative blood test results and coagulation complications in spine surgery patients with a history of COVID-19 infection.

Matherials and Methods

This cross-sectional analytical study was conducted after obtaining the ethical code IR.GMU.REC.1401.066 from the Research Center for Infectious Diseases at Gonabad University of Medical Sciences in 2022. The study involved reviewing the files of 220 patients who had undergone spinal surgery and had reported information about their COVID-19 status in their records. It was conducted between October 1, 2021, and June 1, 2023.

The inclusion criteria for the study consisted of spinal surgery, no history of blood disorders such as deep vein thrombosis (DVT), disseminated intravascular coagulation (DIC), hematologic malignancies, non-pregnancy, non-addiction to drugs and smoking, no history of inflammatory diseases, no history of infectious diseases, no surgical history in the past six months, and non-emergency surgical candidates. The exclusion criteria included incomplete recorded information in the patient's file.

Sampling was performed using a checklist, and the required information was extracted from the Hospital Information System (HIS) within a one-month period and subjected to analysis. The research checklist was designed in three sections. The first section included demographic information of the patients, such as age, gender, weight, type of surgical procedure [fusion surgery and laminectomy], date of surgery, underlying diseases, history of COVID-19 infection, number of vaccine doses received, type of vaccine, and time of the last vaccine dose. The second section included preoperative laboratory test results, including PT, international normalized ratio (INR), PTT, D-dimer, white blood cells (WBC), and platelet counts. The third section included coagulation complications extracted from the patient's record.

Statistical analysis

The obtained data were analyzed using SPSS software version 22. In addition to descriptive methods (such as frequency, percentage, mean, and standard deviation), the independent samples t-test was used to analyze variables such as age, weight, and time of receiving the last COVID-19 vaccine dose. The chi-square test was used to examine the relationship between categorical variables. In this study, a p-value of < 0.05 was considered statistically significant.

Results

To access the raw data of this study, the HMS system of Allameh Bohlol Gonabadi Hospital was utilized. A total of 220 cases that met the inclusion criteria were enrolled in this study and underwent analysis and evaluation. Examination of the data revealed that 124 subjects (56.4%) were male, and

96 subjects (43.6%) were female. Among them, 182 subjects (82.7%) underwent fusion surgery, while 38 (17.3%) underwent laminectomy surgery. A total of 145 subjects (65.9%) had no history of any underlying diseases, while 75 had a history of various underlying conditions. Additionally, a history of COVID-19 infection was observed in 148 subjects (67.3%). Among them, 105 (47.7%) had not received any COVID-19 vaccine, while others had received one or more doses of available vaccines.

Subjects experienced postoperative thrombotic complications, all of which were excessive and uncontrollable bleeding during surgery. Initially, the subjects were divided into two groups based on their history of COVID-19 infection, and no significant differences were observed in any of the variables under investigation.

Subsequently, the subjects were divided into two groups based on the presence or absence of coagulation complications and were compared with each other in terms of the study variables. The results of data analysis using t-tests for age, weight, and time of receiving the last COVID-19 vaccine, and the chi-square test for other demographic variables, did not show any significant differences between the two groups. However, as the results indicated, all subjects who experienced coagulation complications had a history of COVID-19 infection (Table 1).

Furthermore, these two groups were compared in terms of hematological tests using the Mann-Whitney test, and no significant differences were observed in any of the variables (Table 2). One of the other tests examined in this study was D-dimer, which was reported for only 109 participants prior to surgery. Among them, 54 subjects (49.5%) had D-dimer levels within the normal range (less than 500), while 55 (50.5%) had levels above the threshold (500 or higher). The overall mean level of D-dimer, as well as the mean in the group without coagulation complications, exceeded the normal range (500

Table 1: Demographic characteristics and their comparison based on the coagulation complications

Information	Total mean (SD)	No coagulation complications Mean (SD)	With coagulation complications Mean (SD)	p-value
Age (year)	45.9 (13.2)	45.7 (13.2)	55.6 (8.3)	0.100
Weight (Kg)	74.1 (9.0)	74.1 (9.1)	73.6 (5.9)	0.960
Date of last vaccination (month ago)	3.4 (4.2)	3.0 (4.2)	2.8 (2.7)	0.970
	Frequency (Percent)	**No coagulation disorders Frequency (Percent)**	**With coagulation disorders Frequency (Percent)**	**p-value**
Sex				
Male	124 (56.4%)	122 (98.4%)	2 (1.6%)	0.455
Female	96 (43.6%)	93 (96.9%)	3 (3.1%)	
Type of surgery				
Fusion	182 (82.7%)	177 (97.3%)	5 (2.7%)	0.590
Laminectomy	38 (17.3%)	38 (100%)	0 (0%)	
History of underlying disease				
No disease	145 (65.9%)	142 (97.9%)	3 (2.1%)	0.834
Hypertension	22 (10%)	21 (95.5%)	1 (3.8%)	
Diabetes	26 (11.8%)	25 (96.2%)	1 (4.5%)	
Cardiovascular disease	17 (7.7%)	17 (100%)	0 (0%)	
Other	10 (4.5%)	10 (100%)	0 (0%)	
History of covid19				
Yes	148 (67.3%)	143 (96.6%)	5 (3.4%)	0.175
No	72 (32.7%)	72 (100%)	0 (0%)	
Vaccination history				
No Vaccination	105 (47.7%)	103 (98.1%)	2 (1.9%0	0.570
1 dose	10 (4.5%)	10 (100%)	0 (0%)	
2 doses	67 (30.5%)	66 (98.5%)	1 (1.5%)	
≥3 doses	38 (17.3%)	36 (94.7%)	2 (5.3%)	
Type of vaccine				
No vaccine	105 (47.7%)	103 (98.1%)	2 (1.9%)	0.752
Sinopharm	88 (40%)	85 (96.6%)	3 (3.4%)	
Kubrakt	11 (5%)	11 (100%)	0 (0%)	
Other	16 (2.2%)	16 (100%)	0 (0%)	

Table 2: Hematological tests and their comparison based on the coagulation complications

Test	Number	Total		Without coagulation complications		With coagulation complications		p-value
		Mean (SD*)	Median (IQR**)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	
D-Dimer mg/L	109	667.6 (1011.5)	500.0 (320.0)	682.8 (1033.0)	500.0 (337.5)	351.2 (135.3)	376.0 (250.0)	0.195
PT†/s	220	13.1 (1.0)	13.0 (1.4)	13.1 (1.1)	13.0 (1.4)	13.3 (0.76)	13.2 (1.4)	0.370
PTT††/s	220	31.5 (4.9)	31.2 (5.7)	31.5 (5.0)	31.4 (5.8)	30.9 (2.8)	30.3 (5.4)	0.477
INR‡	220	1.0 (0.1)	1.0 (0.1)	1.04 (0.1)	1.0 (0.1)	1.1 (0.6)	1.1 (0.1)	0.279
WBC‡‡ ($\times 10^9$/L)	220	7.9 (3.3)	7.1 (3.3)	7.8 (3.1)	7.1 (3.0)	9.6 (6.3)	6.7 (1.2)	0.997
Plt⁋ ($\times 10^9$/L)	220	276.9 (182.5)	246.0 (950.0)	276.9 (185.1)	245.0 (912.5)	276.4 (131.9)	251.0 (232.5)	0.980

*Standard Deviation, ** Interquartile range, † Prothrombin time, †† Partial thromboplastin time, ‡ International normalized ratio, ‡‡ White blood cells, ⁋ Platelet

Table 3: Demographic characteristics and their comparison based on the D-dimer level

Information	Total Mean (SD)	Normal D-dimer= 500 Mean (SD)	elevated D-dimer≥500 Mean (SD)	p-value
Age (year)	45.9(13.2)	44.8 (11.1)	48.3 (12.1)	0.125
Weight (Kg)	74.15(9.0)	73.2 (9.1)	70.3 (7.6)	0.171
Date of last vaccination (month ago)	3.4(4.2)	5.2 (4.4)	5.4 (4.4)	0.833
	Total Frequency (Percent)	**No coagulation disorders Frequency (Percent)**	**With coagulation disorders Frequency (Percent)**	**p-value**
Sex				
Male	53 (48.6%)	30 (56.6%)	23 (43.4%)	0.151
Female	56 (51.4%)	24 (42.9%)	32 (57.1%)	
Type of surgery				
Fusion	83 (76.1%)	45 (54.2%)	38 (45.8%)	0.081
Laminectomy	26 (23.9%)	9 (34.6%)	15 (65.4%)	
History of underlying disease				
No disease	71 (65.1%)	37 (52.1%)	34 (47.9%)	
Hypertension	15 (13.7%)	5 (38.5%)	8 (61.5%)	0.645
Diabetes	13 (11.9%)	8 (53.3%)	7 (46.7%)	
Cardiovascular disease	7 (6.4%)	2 (28.6%)	5 (71.4%)	
Other	3 (2.7%)	2 (66.7%)	1 (33.3%)	
History of covid19				
Yes	105 (96.3%)	51 (48.6%)	54 (51.4%)	0.363
No	4 (3.7%)	3 (75.0%)	1 (25.0%)	
Vaccination history				
No Vaccination	22 (20.1%)	11 (50.0%)	11 (50.0%)	
1 dose	6 (5.5%)	4 (66.7%)	2 (33.3%)	0.156
2 doses	53 (48.6%)	21 (39.6%)	32 (60.4%)	
≥3 doses	28 (25.6%)	18 (64.3%)	10 (35.7%)	
Type of vaccine				
No vaccine	22 (20.1%)	11 (50.0%)	11 (50%)	
Sinopharm	68 (62.3%)	32 (47.1%)	36 (52.9%)	0.870
Kubrakt	5 (4.5%)	3 (60.0%)	2 (40.0%)	
Other	14 (12.8%)	8 (57.1%)	6 (42.9%)	

Table 4: Hematological tests and their comparison based on the D-dimer level

Test	Total		Normal D-dimer= 500		Elevated D-dimer≥500		p-value
	Mean (SD*)	Median (IQR **)	Mean (SD)	Median (IQR)	Mean (SD)	Median (SD)	
PT†/s	13.2 (1.1)	13.1 (1.5)	12.9 (1.0)	12.8 (1.4)	12.9 (1.1)	12.8 (1.2)	0.959
PTT††/s	31.5 (4.9)	31.4 (5.7)	31.7 (3.8)	31.9 (4.6)	31.3 (5.7)	31.3 (7.0)	0.365
INR‡	1.0 (0.1)	1.0 (0.1)	1.0 (0.1)	1.0 (0.1)	1.0 (0.1)	1.0 (0.1)	0.508
WBC‡‡ ($\times 10^9$/L)	7.0 (3.3)	7.1 (3.3)	7.6 (3.2)	6.7 (2.2)	8.2 (3.4)	7.6 (4.0)	0.314
Plt⁋ ($\times 10^9$/L)	276.9 (182.5)	246.0 (950.0)	251.7 (746.8)	245.0 (101.5)	301.6 (244.7)	248.0 (101.0)	0.335

*Standard Deviation, ** Interquartile range, † Prothrombin time, †† Partial thromboplastin time, ‡ International normalized ratio, ‡‡ White blood cells, ⁋ Platelet

milligrams per liter), whereas in the group with coagulation complications, this mean was within the normal range.

Based on the D-dimer level, participants were divided into two groups. In one group, 54 subjects (49.5%) with D-dimer levels below 500 [normal range] were included, and in the other group, 55 subjects (50.5%) with D-dimer levels above 500 were included. These two groups were then compared in terms of demographic information, such as weight, age, and time interval since the last dose of COVID-19 vaccination, using the t-test, and the chi-square test was applied for other demographic variables including type of surgery, underlying medical history, history of COVID-19 infection, and vaccination status [Table 3]. The results of the Mann-Whitney test also did not show significant differences in the hematological variables between the two groups based on D-dimer levels [normal and elevated ≥500] [Table 4].

Discussion

Spinal surgeries can be complex and time-consuming, and along with the patient's prior medical history, they inherently carry potential adverse outcomes. Performing hematological tests and blood cell counts can partially predict and mitigate these complications by delaying surgery and controlling certain factors.

Furthermore, in another study, patients in two groups with severe and moderate COVID-19 were compared in terms of coagulation factors. The results showed that, in the severe COVID-19 group, the levels of PT, PTT, and INR were higher, and platelet counts were lower compared to the other group, which led to thrombocytopenia and DIC in these individuals. Consequently, the mortality rate was also higher in this group [15]. However, it should be noted that these studies examined hematological tests simultaneously with COVID-19 infection, whereas in our study, INR was measured as a laboratory test prior to surgery in individuals with a history of COVID-19 to ensure the absence of any effects on surgery. In this regard, the Indian Society of Anesthesiologists has also listed the measurement of preoperative INR in patients with a history of COVID-19, both with and without side effects, as one of the important tests [16].

Nevertheless, in our study, these differences were not observed, indicating that after a certain period of recovery from COVID-19, in individuals who had at least three months since their last vaccine dose, coagulation status and hematological results return to normal, and patients can be prepared for major surgeries such as spinal surgery. On the other hand, the results of this study showed that despite the increase in the average level of D-dimer compared to the normal state, other coagulation tests were normal. Not only did the two groups—with and without coagulation complications—not show a significant difference in terms of D-dimer levels, but the average level of this test was lower in the group with coagulation complications than in the other group.

Similarly, in their study, Anna Jungwirth Weinberger et al. [17] examined 2,366 patients undergoing knee and hip joint replacement surgeries for D-dimer levels, surgical coagulation complications, and COVID-19 infection up to six weeks after the operation. In this study, there was no significant difference in D-dimer levels between COVID-19-positive and COVID-19-negative patients. Only 10 patients experienced coagulation complications, and 8 of them had D-dimer levels within the normal range. The results of this study, like our own, do not support D-dimer testing as an appropriate method for predicting coagulation complications. However, some other studies have considered D-dimer testing a suitable method in this regard [16].

As Xiaokang He et al. [18] found in their study—categorizing COVID-19 patients into deceased, severely ill, and mild cases—they concluded that D-dimer levels were significantly higher than normal in deceased patients. Severe COVID-19 infection also increased the likelihood of elevated D-dimer levels compared to mild COVID-19. In another study, elevated D-dimer levels in recovered COVID-19 patients were introduced as a means of diagnosing COVID-19-related lung complications [19].

Based on these studies, it can be stated that the elevation of D-dimer levels during COVID-19, and their persistence after recovery, may be due to damage caused by the virus to various organs. Although elevated D-dimer levels during infection may help predict the occurrence of thrombotic complications and guide clinical decision-making, our study indicates that following recovery from COVID-19—particularly before invasive procedures such as spinal surgery—D-dimer test results are no longer reliable and cannot be considered helpful in the same manner.

Conclusions

The results obtained from this study showed that in the post-COVID-19 period, among patients with a history of COVID-19, for major and lengthy surgeries such as spinal surgery—which carry a high risk of excessive bleeding at the surgical site or the occurrence of DVT and DIC—the evaluation of D-dimer test results is no longer as helpful as in the past. However, it should be noted that the low number of coagulation complications observed in this study may be attributable to the limited sample size, which could influence the findings. Therefore, researchers recommend conducting comprehensive evaluations of coagulation tests in surgical candidates with a history of COVID-19 on a larger scale and with a higher sample size to obtain more robust and generalizable results.

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Ethical Approval

Ethical approval was granted by Ethics Committee of Gonabad University of Medical Sciences (Ethics No. IR.GMU.REC.1401.066). Cord blood was collected at Allameh Bohlol Gonabadi Hospital affiliated to Gonabad University of Medical Sciences from Hospital Information System (HIS).

Consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

Raw data were generated at Gonabad University of Medical Sciences. Derived data supporting the findings of this study are available from the corresponding author on request.

Competing Interests

Authors declare no conflict of interests.

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Authors Contribution

All authors contributed to the idea and writing part of the article. F.P and M.Z and M.M designed the study and wrote the manuscript. A.M contributed in data collection and draw the schematic tables. M.Z and A.T wrote some parts of the manuscript. M.Z reviewed and revised the text. M.Z and A.T edited the manuscript and submitted the paper. A.M contributed to data analysis. F.P has handled whole correspondence during the paper submission, handling the revisions and re-submission of revised manuscripts up to the acceptance of the manuscripts. All authors read and approved the final version of the work to be published.

Abbreviation	Definition
COVID-19	Coronavirus disease 2019
CRP	C-reactive protein
DVT	Deep vein thrombosis
DIC	Disseminated intravascular coagulation
ESR	Erythrocyte sedimentation rate
HIS	Hospital Information System
INR	International normalized ratio
MERS	Middle East respiratory syndrome
PTT	Partial thromboplastin time
PT	Prothrombin time
SARS	Severe acute respiratory syndrome
VTE	Venous thromboembolism
WBC	White blood cells
WHO	World Health Organization

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