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Comparison of D-dimer values among COVID-19 patients with and without type 2 diabetes mellitus

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Abstract:

Individuals with Type 2 Diabetes Mellitus (T2DM) especially those with vascular complications exhibit elevated D-dimer levels. Therefore, it is of interest to evaluate the D-dimer concentrations in subjects with COVID-19, with and without Type 2 Diabetes Mellitus (T2DM). The mean D-dimer concentration was significantly higher among those with T2DM than those without T2DM (228.45 vs 112.74 ng/mL) ($p=0.05$). The D-dimer level was found to be abnormal in 52.2 % of diabetic patients and it was 47.8 % in non-diabetics, making it clinically significant. The mean D-dimer levels with respect to diabetes control and other inflammatory biochemical parameters, such as CRP, Ferritin and LDH, were higher in patients with diabetes than in non-diabetics. These outcomes indicate the concept that the presence of diabetes along with COVID-19 could further enhance the hypercoagulable condition induced by SARS-CoV-2 infection, thus exhibiting a higher likelihood of thrombotic complications and worse clinical outcomes.

Keywords: Chest X-ray, COVID-19, D-dimer, HbA1c, Type 2 diabetes mellitus (T2DM)

Background:

Type 2 diabetes mellitus (T2DM), a key factor contributing to global morbidity and mortality, is linked to many microvascular and macrovascular problems that affect the quality of life for patients. Numerous studies demonstrate that T2DM patients, especially those infected with the SARS-CoV-2 virus, exhibit a greater frequency of hospital admission, an increased likelihood of developing severe pneumonia and increased fatality rates in comparison to individuals without comorbidities [1, 2]. T2DM is a persistent inflammatory condition that significantly impairs the response to infections, especially in individuals with uncontrolled glycemia, due to reduced innate and humoral responses. Hyperglycemia can impair immune response; however, an aberrant immunological state is associated with macrovascular consequences of diabetes mellitus. T2DM is linked to immunological dysfunction, which may resemble accelerated ageing and possibly elucidate the adverse prognosis in individuals with T2DM and COVID-19 infection [3]. In certain individuals, the infiltration of the SARS-CoV-2 virus into human cells induces a "cytokine storm" by activating inflammatory responses, which involve the acquisition of T helper cells and the synthesis of different interferons. The elevation of this cytokine profile may render individuals with T2DM and COVID-19 more vulnerable to organ dysfunction, potentially resulting in multifaceted organ failure, as indicated in the severe course of the condition [4]. D-dimer is the primary degradation product of fibrin and serves as a biomarker for both fibrin production and degradation. Multiple studies have showed that D-dimer is an important indicator of coagulation and fibrinolysis activity. Healthy individuals exhibit low circulation D-dimer concentration, but increased levels are observed in disorders linked to thrombosis and inflammation. D-dimer has been thoroughly studied for the diagnosis, tracking and therapy of venous thromboembolism, for which it is widely employed. The levels of D-dimer are high in chronic inflammatory disorders, including malignancies, rheumatoid arthritis, sickle cell anaemia and asthma. During the COVID-19 pandemic, elevated D-dimer levels have been seen in non-survivors and patients with serious medical conditions. The occurrence of outcomes at various D-dimer levels, both at clinical presentation and throughout hospitalisation, is inadequately defined. The progression of D-dimer in individuals with COVID-19 continues unexamined,

despite the observation of extensive microthrombi in various organ systems associated with the disease [5]. Research indicates that individuals with T2DM, particularly those with microvascular and macrovascular problems, exhibit elevated levels of D-dimer. It is yet to be determined whether D-dimer levels in individuals with diabetes vary from those in individuals without diabetes, before concluding that it is a contributing factor to severe COVID-19, indicating heightened vulnerability to thromboembolic conditions [6]. Therefore, it is of interest to evaluate the D-dimer concentrations among individuals with and without COVID-19 and T2DM.

Materials and Methods:

This non-interventional, retrospective investigation was undertaken in the Department of Medicine at Dr. TMA Pai Hospital in the Udupi district of Karnataka, affiliated with Manipal Academy of Higher Education, Manipal. Patients diagnosed with COVID-19 using RTPCR testing of nasopharyngeal swab samples were included. Positive results on the reverse-transcriptase polymerase chain reaction (RT-PCR) test of nasal and pharyngeal swab samples are considered definitive cases of COVID-19. A review of all laboratory-confirmed COVID-19 cases admitted from 1 March 2020 to 30 September 2020 identified 432 patients for inclusion in this investigation. Individuals over 18 years of age diagnosed as COVID-19 positive per WHICH standards were enrolled in the study. Patients with Type 1 Diabetes Mellitus (T1DM), a prior history of thromboembolism and disseminated intravascular coagulation (DIC), individuals on heparin, pregnant and lactating women, those with pre-existing chronic renal failure (CKD) or chronic liver dysfunction (CLD), patients with known malignancies that are not in remission, individuals with recent lower limb fractures, recent deep vein thrombosis, recent pulmonary embolism and those who have undergone recent surgical procedures were excluded. Demographic and clinical characteristics were obtained from medical documents with a standardised data collection instrument. The date of admission, symptoms, coexisting conditions, oxygen requirements and other information were recorded. The participants were classified into three groups: individuals without T2DM by ADA standards, individuals with controlled T2DM and individuals with uncontrolled T2DM. The D-dimer levels of the patients

were assessed using either a biochemical methodology with the Cobas C311 analyser or a coagulation method with the Werfen Acl Elite analyser. During the COVID-19 pandemic, according to the guidelines established by the Government of India, all those who were diagnosed as COVID-positive were required to be admitted immediately after diagnosis, regardless of symptom intensity and were discharged only after a period of 10 days from the emergence of symptoms or the date of diagnosis for asymptomatic patients. Consequently, the onset date of symptoms and the date of the RTPCR swab test were recorded for all patients. Laboratory results were extracted from computerised medical documents. All laboratory procedures were conducted in accordance with the patient's clinical care requirements. Laboratory evaluations included a complete blood count, biochemical analysis encompassing liver and renal function, electrolytes, C-reactive protein (CRP), lactate dehydrogenase, ferritin, D-dimer and chest X-ray for all patients. Additional tests, including serum Procalcitonin, blood culture and other pertinent assessments, were conducted as warranted by the patient's health status. All aforementioned blood tests and imaging findings were documented.

Statistical analysis:

Data entry was subjected to statistical analysis utilising the Statistical Package for Social Sciences (SPSS Version 16.0) for Microsoft Windows. A descriptive statistical analysis was conducted to examine the distribution of various categorical and quantitative variables. Categorical data were presented as percentages, whilst quantitative variables were expressed as mean $\pm$ SD. The t-test was employed to evaluate the statistical significance of the difference between the two groups, while the Chi-square test was employed to test categorical variables. A P-value below 0.05 is deemed statistically significant.

Results:

The study had 432 people, with males constituting 64.6% (n=279) and females 35.4% (n=153). The age group of 51 to 60 years (n=92; 21.3%) and 61 to 70 years (n=91; 21.1%) comprised the greatest proportion of the patients. The following age groups were further divided: 41 to 50 years (n=76; 17.6%), more than 71 years (n=61; 14.1%), 31 to 40 years (n=59; 13.7%), 21 to 30 years

(n=42; 9.7%) and 18to20 years (n=11; 2.5%). The average age was 52.72 ± 16.85 years. In 76.6% (n=331) of patients, the hospital stay lasted less than ten days, 21.8% (n=94) experienced stays of 11 to 20 days and 1.6% (n=7) had stays of 21 to 30 days. The average length of stay was 8.98 ± 3.98 days. The distribution of patients according to symptomatology was as follows: fever (n=261; 60.4%) was the predominant symptom, followed by cough (n=161; 37.3%), dyspnoea (n=60; 13.8%), myalgia (n=32; 7.4%), sore throat [n=27; 6.3%], headache (n=19; 4.4%) and diarrhoea (n=18; 4.2%). 33.8% (n=146) of the individuals were asymptomatic. The distribution of patients according to comorbidities was as follows: hypertension (n=183; 42.4%), type 2 diabetes mellitus (n=183; 42.4%), ischaemic heart disease (n=47; 10.9%), thyroid condition (n=30; 6.9%), bronchial asthma (n=20; 4.6%), chronic obstructive pulmonary disease (n=8; 1.9%) and neuromuscular disorders (n=4; 0.9%). The mean HbA1c, FBS and PPBS levels, TC, urea, creatinine, sodium, potassium, indirect bilirubin, aspartate transaminase, CRP, ferritin and LDH were significantly higher among those with T2DM (p<0.01). The mean Haemoglobin, PLC, total bilirubin, alanine transaminase, alkaline phosphatase and albumin levels didn't show much difference between patients with or without diabetes mellitus (p>0.05) (**Table 1**). The average D-dimer levels were significantly higher among those with diabetes mellitus (228.45 vs 112.74 ng/mL) (p=0.05). The average D-dimer levels were higher in patients with >7 HbA1c levels when compared to those of HbA1c ≤ 7 , though the difference is statistically insignificant (p=0.48) (**Table 2**). Among patients with diabetes mellitus, severe chest x-ray findings were found in a significantly higher proportion compared to patients without diabetes (p=0.01) and were observed to be statistically significant (**Table 3**). Out of 183 T2DM subjects, 52.2% had >0.5 mg/l D-dimer values and 66.7% (n=150/249) of subjects without T2DM had <0.5 mg/L D-dimer values. The difference was found to be statistically significant (p=0.001) (**Table 4**). The mean D-dimer levels among <65 years patients were higher in patients with >7 HbA1c levels. The mean D-dimer levels among ≥ 65 years or older were higher in patients with >7 HbA1c levels. However, the difference in D-dimer values with respect to age and Hb1Ac was observed to be statistically insignificant (**Table 5**).

Table 1: Summary of the blood investigation reports among patients with and without T2DM

	Diabetes Mellitus				T-test	P-value
	YES (n=183)		NO (n=249)			
	Mean	SD	Mean	SD		
HbA1c	8.22	2.01	5.73	0.94	17.16	<0.001**
FBS	173.26	69.06	111.69	25.72	12.91	<0.001**
PPBS	237.39	79.00	152.41	39.01	14.71	<0.001**
Haemoglobin (g/dL)	12.58	1.63	12.70	1.53	-0.78	0.43
TC (cells/litre)	2644.30	434.10	2336.99	369.91	7.92	<0.001**
PLC (X1000)	258.22	101.02	255.32	74.53	0.34	0.73
Urea (mg/dL)	28.42	14.03	20.61	7.58	7.43	<0.001**
Creatinine (mg/dL)	0.88	0.24	0.80	0.22	3.59	<0.001**
Sodium (mEq/L)	135.88	5.24	137.92	4.78	-4.21	<0.001**
Potassium (mmol/L)	4.21	0.47	4.07	0.40	3.34	0.001**
Total bilirubin (mg/dL)	0.50	0.23	0.50	0.27	0	1
Direct bilirubin (mg/dL)	0.20	0.11	0.18	0.11	1.87	0.06
Indirect bilirubin (mg/dL)	0.90	0.22	0.81	0.32	3.28	0.001**
Aspartate transaminase (U/L)	42.45	28.48	34.43	27.83	2.93	0.004**

Alanine transaminase (U/L)	40.27	30.94	34.52	36.87	1.71	0.09
Alkaline phosphatase (U/L)	81.06	31.57	79.41	25.81	0.60	0.55
Albumin (g/dL)	5.46	1.61	5.62	1.53	-1.05	0.29
CRP (mg/L)	55.87	64.25	18.77	35.60	7.65	<0.001**
Ferritin (ng/mL)	478.74	497.51	279.39	359.55	4.83	<0.001**
LDH (U/L)	314.15	101.10	272.51	192.16	2.67	0.008**

Table 2: Comparison between mean D-dimer levels among those with and without T2DM and HbA1c levels in all patients (n=432)

		Mean	SD	t-test	p-value
D-dimer (ng/mL)	With T2DM	229.00	730.00	1.97	0.05*
	Without T2DM	112.74	499.00		
D-dimer (ng/mL)	HbA1c ≤7	147.53	637.73	-0.69	0.48
	HbA1c >7	190.81	549.21		

Table 3: Comparison of chest X-ray findings of the study sample

		Chest X-ray findings		Total	Chi-Square	p-value
		Severe	Non-Severe			
Diabetes Mellitus	Yes	n	62	121	37.27	0.01**
		%	71.3%	35.1%		
	No	n	25	224		
		%	28.7%	64.9%		
Total	n	87	345	432		
	%	100.0%	100.0%	100.0%		

**Statistically significant

Table 4: Comparison of D-dimer levels based on the presence or absence of T2DM

		D-DIMER		Total	Chi-Square	p-value
		Normal (<0.5 mg/l)	Abnormal (>0.5 mg/l)			
Diabetes Mellitus	Yes	n	75	108	15.67	0.001**
		%	33.3%	52.2%		
	No	n	150	99		
		%	66.7%	47.8%		
Total	n	225	207	432		
	%	100.0%	100.0%	100.0%		

**Statistically significant

Table 5: Comparison between D-dimer levels and HbA1c levels in patients with age <65 years and ≥65 years

	HbA1c	N	Mean	SD	T Test	P Value
D-dimer (ng/mL) level in patients aged <65 years (n=312)	≤7	218	151.1	726.27	-0.56	0.57
	>7	94	200.49	658.45		
D-dimer (ng/mL) in patients with age ≥65 years (n=120)	≤7.5	85	131.42	200.98	-1.57	0.11
	>7.5	35	197.76	228.90		

Discussion:

The present study assessed D-dimer levels in COVID-19 individuals with and without T2DM and found significantly increased D-dimer concentrations in those with T2DM. This finding corroborates the notion that the coexistence of diabetes and COVID-19 may exacerbate the hypercoagulable state triggered by SARS-CoV-2 infection, hence elevating the likelihood of thrombotic events and adverse clinical consequences. Increased D-dimer concentrations have frequently been identified as markers of coagulation activation, disease severity and death in COVID-19 [7, 8]. A study involving 174 patients hospitalised with COVID-19 revealed markedly elevated serum levels of interleukin 6, erythrocyte sedimentation rate, CRP, ferritin, fibrinogen and D-dimer in individuals with T2DM relative to those without diabetes. Pre-existing coexisting medical conditions linked to diabetes, such as hypertension, coronary artery disease and chronic renal disease, exacerbate the prognosis. Finally, hypoglycemia, which can develop during T2DM treatment, might further exacerbate clinical results [9]. Mortality related to COVID-19 is predominantly linked to hypercoagulability and an elevated risk of venous thromboembolism, resulting in thromboembolic complications

and inflammation in extreme cases [10]. Consequently, coagulation biomarkers may reflect illness severity and mortality, assisting in patient triage, therapeutic options and prognosis. D-dimer is a byproduct of fibrin degradation and serves a mechanistic function in thrombo-inflammation associated with COVID-19. Numerous studies have associated elevated D-dimer levels (prevalence of 46.4%) with heightened severity and negative consequences of COVID-19. Patients exhibiting D-dimer levels exceeding 1000 ng/mL face a 20-fold increased mortality risk relative to individuals with lower D-dimer levels. D-dimer serves as a prospective screening instrument for venous thromboembolism in COVID-19 patients and modifying therapeutic anticoagulant dosages based on elevated D-dimer levels is more advantageous for patients than administering preventive doses. D-dimer concentration levels should be evaluated in COVID-19 patients shortly after admission [11]. Consistent with the current study's results, Sukrisman and Sinto [12] reported that males constituted 62.4% and females 37.6%. Likewise, Shang *et al.* [13] reported that the predominant initial symptom of the disease was fever, followed by cough, corroborating the findings of the current investigation. This investigation identified the following comorbidities:

hypertension (42.4%), type 2 diabetes mellitus (42.4%), ischaemic heart disease (10.9%), thyroid condition (6.9%), bronchial asthma (4.6%), chronic obstructive pulmonary disease (1.9%) and neuromuscular disorders (0.9%). T2DM patients had a higher prevalence of concomitant hypertension compared to non-diabetic patients [14]. Sukrisman and Sinto [12] identified hypertension as the most prevalent comorbidity, followed subsequently by renal disease and T2DM at 30.9%. Shang *et al.* [13] reported that over half of the patients presented with at least one of the comorbidities, comprising hypertension, T2DM, cardiovascular disease, chronic respiratory illness, chronic liver impairment, malignancy and chronic renal diseases. The physiological inflammatory response commences rapidly upon tissue damage. A systemic symptom of this inflammatory mechanism is an elevation in acute-phase proteins, including CRP and ferritin [15]. Elevated CRP and D-dimer values are strongly associated with severe COVID-19 infection and ICU admission, as showed by Kumar *et al.* these biomarkers may be useful for early detection of high-risk patients and for prompt clinical judgement. Continuous tracking of these markers is suggested to improve clinical results [16]. Our findings align with prior research indicating elevated D-dimer levels in diabetic individuals afflicted with COVID-19. Sharma *et al.* [17] established that D-dimer and inflammatory indicators were markedly elevated in COVID-19 individuals with T2DM compared to those without, indicating that T2DM exacerbates the inflammatory and thrombotic response to SARS-CoV-2 infection. Bayraktar *et al.* [18] similarly showed increased blood D-dimer levels among individuals with both COVID-19 and T2DM, highlighting the combined effect of these diseases on coagulation dysfunction. The increased D-dimer concentrations observed in diabetic COVID-19 subjects are due to the intrinsic prothrombotic milieu associated with T2DM. Chronic hyperglycemia causes endothelial dysfunction, platelet hyperreactivity, oxidative stress and low-grade systemic inflammation, all of which contribute to the facilitation of the stimulation of the coagulation pathway. SARS-CoV-2 infection may result in the interaction of the endothelial damage and the cytokine-mediated inflammatory response, which may lead to excessive fibrin production and breakdown, as evidenced by elevated D-dimer levels [18, 19]. The present findings are concurrent with the findings of Viswanatha Setty *et al.* [19], who reported significantly higher levels of D-dimer in symptomatic COVID-19 subjects with T2DM as compared to asymptomatic diabetic SARS-CoV-2 infected individuals. The study also showed a positive correlation between D-dimer concentrations and the extent of the disease, emphasising the importance of coagulation markers in the management of diabetic COVID-19 patients. Together, these data show that D-dimer may be an important predictive biological marker in this at-risk population. Another potential reason for elevated D-dimer values in diabetic patients could be insulin resistance and chronic inflammation. Diabetes has been associated with the increased expression of pro-inflammatory cytokines, interleukin-6 and tumour necrosis factor- α , which promote hepatic production of coagulation factors and inhibit fibrinolysis. The cytokine storm induced by

COVID-19 infection worsens endothelial injury and microvascular thrombosis, accompanied by elevated D-dimer levels [20, 21]. Therefore, T2DM subjects with COVID-19 who have elevated D-dimer levels might warrant more intensive monitoring, timely thromboprophylaxis when indicated and rigorous management of glycaemic control. While the results of this study showed a substantial difference in D-dimer values between those with and without diabetes, sub-group analysis with various age groups and genders did not show a significant difference. This is probably due to the modest sample size. A similar study with a larger sample size would better demonstrate such differences and indicate the specific risk factors in the group with diabetes mellitus.

Conclusion:

The mean D-dimer concentrations were significantly higher among COVID-19 subjects with T2DM than those without diabetes. COVID-19 subjects with T2DM were found to have a significantly higher proportion of severe chest X-ray findings when compared to non-diabetics. These outcomes indicate that patients with diabetes mellitus, irrespective of glycemic control, had a higher D-dimer value (indicating a higher risk of microthrombi) and severe COVID-19 changes in the chest X-ray.

Advancement to knowledge:

The study found higher D-dimer levels in COVID-19 patients with T2DM, suggesting that diabetes may worsen the COVID-19-related hypercoagulable state and increase the risk of thrombosis and poor outcomes. Elevated D-dimer is also a recognized marker of coagulation activation and severe disease in COVID-19.

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