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REVIEW

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A systematic review of the venous thromboembolism prevalence and related risk factors in patients with Covid-19

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Abstract

Introduction The present study was performed to evaluate the pooled prevalence of the venous thromboembolism (VTE) and the factors affecting its incidence in patients who are affected with coronavirus disease (Covid-19).

Patients and methods A systematic review and meta-analysis were carried out by searching all the authentic online databases. The study includes papers worldwide since 2019 to 2022. After assessing related articles, the required information was collected based on a prepared checklist and analyzed by STATA software.

Result According to the estimates, pooled prevalence of VTE among patients with Covid-19 was 0.17 (95% *CI* = 0.13–0.22, *P* = 0.000). Analysis of prevalence values of VTE in patients with Covid-19 based on geographical areas showed statistically significant differences emerged from the study results. Analyses showed that stroke is a significant risk factor.

Discussion The present study showed a relatively high prevalence of VTE in patients infected with coronavirus. Results of study showed that prevalence of VTE is significantly differ according to geographical areas; it can be concluded that racial differences and genetic factors can affect the VTE incidence in Covid-19-affected patients. Additionally, a history of stroke and cerebrovascular events can be a risk factor indicating the need for prophylactic anticoagulant treatment in these patients, but history of respiratory disease, cardiovascular disease, hypertension, diabetes, dyslipidemia, liver disease, malignancy, and smoking is not risk factors of VTE in patients affected with Covid-19.

Keywords Venous thromboembolism, Systematic review, Meta-analysis, Prevalence, Covid-19, Risk factor

Introduction

Initially spotted in Wuhan in December, Covid-19 spread rapidly worldwide [1]. Coronavirus is a fast-mutating single-stranded RNA virus that acts by linking with angiotensin-converting enzyme 2 (ACE2) receptors, particularly in the lungs and heart [2]. The Covid-19 virus uses ACE2 receptors to enter cells through add of the virus. However, it may bind to other receptors. Studies demonstrated that ACE2 is essential in viral proliferation [3].

Covid-19 involves various organs in the body and is not limited to the lungs [4]. A wide variety of disorders can be caused by the virus, including asymptomatic affection to severe systemic involvement and acute respiratory distress syndrome [5]. Systemic manifestations of this disease include hematologic disorders and increased incidence of thrombotic complications [6, 7]. A high prevalence of thrombotic complications has been reported in

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critically ill patients [8]. Patients admitted to intensive care units (ICUs) are more likely to suffer from VTE [9]. Covid-19 is most commonly associated with pulmonary embolism [10]. Studies on autopsies have also shown a high prevalence of thromboembolic events leading to respiratory failure [11]. The exact pathophysiology and the primary mechanism of clinical responses to Covid-19 are still unclear [12]. In severe cases, Covid-19 leads to cytokine release, platelet activation, endothelial dysfunction, and sepsis-related coagulopathy [13]. Coronavirus causes pneumonia in almost all patients and leads to cytokine storms in much more serious cases where inflammation stimulates the activation of coagulation [14]. During the early stages of the disease, inflammation of the alveolar vascular endothelium can stimulate the development of pulmonary clots and activate neutrophils to inhibit viral invasion [15]. In addition, the virus itself can trigger the coagulation cascade [16]. Studies have been performed to investigate the prevalence of thrombotic complications in Covid-19 disease and the factors affecting the occurrence of these complications. As comprehensive and complete results are unavailable, this meta-analysis can be helpful for researchers and scientists.

Patients and methods

Study outline

The present study was conducted based on Meta-analysis Of Observational Studies in Epidemiology (MOOSE) standards. It was reported using the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) published guidelines [17, 18]. The study was conducted by two independent researchers at all stages, and any discrepancies were examined by a third person.

Search strategy

The comprehensive search was operated using exact MeSH keywords, including "Covid-19"[MeSH], "venous thromboembolism"[MeSH], "deep vein thrombosis"[MeSH], and "pulmonary thromboembolism "[MeSH] in all confirmed online databases like CINAHL, Web of Science (ISI), and PubMed/Medline. Additionally, without considering any time limitation, our MeSH terms were searched in international publishers such as Wiley online library, Science Direct, and Springer since 2019 until February 2022. All databases were searched in English, and all articles were retrieved in English to remove any potential language bias. References from the retrieved articles were also analyzed.

Eligibility criteria for inclusion and exclusion

Cohort studies that assessed the prevalence and risk factors of VTE [deep vein thrombosis (DVT) or pulmonary thromboembolism (PTE)] in Covid-19 patients were taken into consideration. Exclusion criteria were as follows:

1. Non-English language articles
2. Non-cohort articles
3. Insufficient data
4. Non-related subject
5. Thesis, case studies, review articles, conference presentations, and letters to editors

Data extraction

The extracted data for this meta-analysis were as follows: Author's name, study period, year of publication, number of Covid-19 patients, country, patient's admission in ICU or ward, characteristics of samples [e.g., mean age and standard deviation (SD), total sample size, men and women, body mass index (BMI), underline disease, history of smoking], and VTE rate. These data were collected for VTE and non-VTE patients in studies assessing the risk factors of VTE in Covid-19 patients.

Quality assessment

Study quality was assessed using the Newcastle–Ottawa scale (NOS), and studies with a score of 5 were included in the analysis [19].

Statistical analysis

The studies collected were grouped into two categories: the prevalence of VTE in patients with Covid-19 and the risk factors associated with VTE in these patients. In order to combine the results of different studies, the random-effects model was utilized. As a result of the Q Cochrane test and the I^2 index, heterogeneity was assessed and interpreted [20]. To elucidate the causes of heterogeneity between studies, subgroup analyses were conducted based on geographical localization. Analyzing the data was done using STATA version 12. Data analyses were displayed as plots, flowcharts, and tables. The significance threshold was set at less than 0.05.

Results

Search results and characteristics

After the comprehensive search in mentioned databases, 765 papers were gathered, of which 336 articles were excluded due to duplication. According to the abstracts, 129 studies were removed for not being related to the topic, having insufficient information, or not being in English. A total of 214 studies were excluded because of inadequate information, leaving 86 studies for the final analysis. Finally, in two groups

(cohort and RCT), studies were analyzed (Fig. 1). Table 1 summarizes the collected data.

By analyzing the data of 37 studies, there was a 0.17 prevalence rate of VTE among Covid-19 patients (95% $CI = 0.13–0.22$, $P < 0.0001$), and the heterogeneity rate in this study was 98.8% which was statistically significant ($P < 0.0001$) (Fig. 2).

VTE prevalence in Covid-19 patients by geographical distribution

In studies conducted in Europe, a prevalence rate of 0.23 was calculated for VTE among patients with Covid-19 (95% $CI = 0.15–0.32$). In studies conducted in the USA, Asia, and Australia, the prevalence was estimated to be 0.093 (95% $CI = 0.043–0.16$), 0.073 (95% $CI = 0.21–0.003$), and 0.03 (95% $CI = 0.025–0.04$), respectively. Statistically significant differences emerged from the study results ($P < 0.0001$) (Table 2).

Risk factors for VTE prevalence among patients with Covid-19 affecting the VTE incidence among patients with Covid-19

The analysis of 49 studies, the factors affecting the incidence of VTE in Covid-19 patients, was examined; analysis showed that immunodeficiency, history of kidney disease, and history of stroke were significant risk factors with prevalences of 0.52 (95% $CI = 0.28–0.98$), 0.36 (95% $CI = 0.26–0.5$), and 2.04 (95% $CI = 1.09–3.8$), respectively (Table 3).

Discussion

A large number of Covid-19 patients develop VTE despite the use of anticoagulants [7, 106]. Timely detection and treatment of VTE in these patients can reduce mortality. Also, using anticoagulants as prophylaxis can be effective [107]. In addition to the risk of thrombotic complications, patients with Covid-19 are also at risk of bleeding, so anticoagulants should be used with caution in these patients [42]. The current study showed average prevalence of VTE in patients with Covid-19 was 17%.

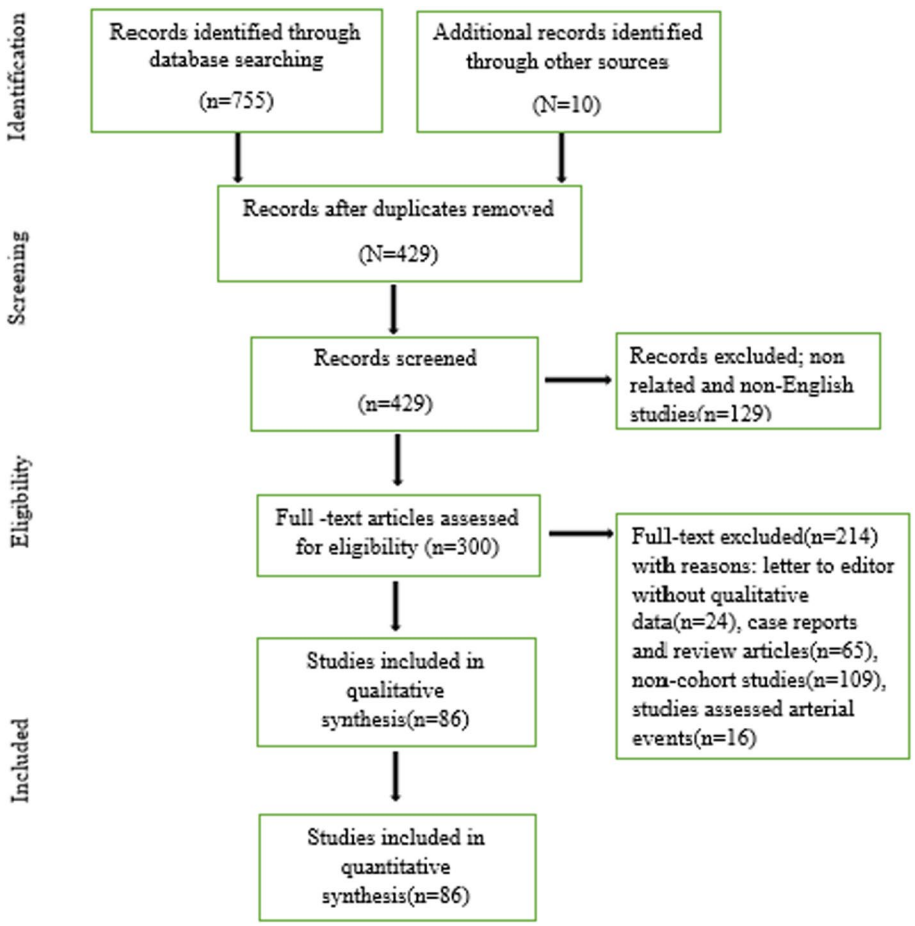

Fig. 1 PRISMA flowchart

Table 1 Data obtained from review of studies on prevalence of VTE patients with COVID-19

Author, year, country(ref.)	Admit	VTE	Study period	Patients (*n*)	Mean age (SD)	Man/woman	Mean BMI	VTE (*n*)
Al-Samkari (2020), US [21]	ICU, GW	PTE, DVT	Mar 1-Apr 5, 2020	400	62.5	228/172		19
Avruscio (2020), Italy [22]	ICU, GW	PTE, DVT	Mar 4-Apr 30, 2020	85	67 (11)	61/24		40
Barrett (2020), US [23]	-	VTE	-	100	65	61/39		8
Cui (2020), China [24]	ICU	DVT	Jan 30-Mar 22, 2020	81	59.9 (14.1)	37/44		20
Franco-Moreno (2020), Spain [25]	-	PTE, DVT	Mar 30-May 6, 2020	26	60	15/11		2
Freund (2020), France [26]	-	PTE	Feb 1-Apr 10, 2020	974	61 (19)			500
Hanif (2020), US [27]	-	VTE	Mar 15-Apr 14, 2020	921	62	574/347	30.4	16
Helms (2020), France [28]	ICU	PTE, DVT	Mar 3 to 31 2020	150	63	122/28		28
Hill (2020), Australia [29]	-	PTE, DVT	Mar 1-May 1, 2020	2748				86
Jimenez-Guiu (2020), Spain [30]	Noncritically ill	DVT	Apr 2020	57	71.3	29/28		6
Klok (2020), Netherlands [31]	ICU	PTE, DVT	Mar 7-Apr 5, 2020	184	64			68
Llitjos (2020), France [32]	-	PTE, DVT	Mar 19-Apr 11, 2020	26	68	20/6	30.2	18
Lodigiani (2020), Italy [33]	ICU, GW	PTE, DVT	Feb 13-Apr 10, 2020	388	66	264/124		16
Longchamp (2020), Switzerland [34]	ICU	PTE, DVT	18 and 30 May 2020	25	68 (11)	16/9	27.5	8
Marone (2020), Italy [35]	-	PTE, DVT	Mar 1-Apr 25, 2020	101				58
Mazzaccaro (2020), Italy [36]	GW	PTE	Mar 18-Apr 20, 2020	32	68.6 (12)	23/9	27.1 (4.3)	21
Mei (2020), China [37]	-	PTE, DVT	Jan 1-Mar23, 2020	256	55.5	131/125		5
Patel (2020), UK [38]	ICU	PTE	Mar 17-Apr10, 2020	39	52.5	32/7	31.3 (6.1)	15
Pavoni (2020), Italy [39]	ICU	DVT	Feb 28-Apr 10, 2020	40	61 (13)	24/16	28.4 (4.7)	8
Pierfranceschi (2020), Italy [40]	-	DVT	Feb 21-end of Mar	66	71.5 (11)	46/20		9
Rieder (2020), Germany [41]	-	PTE, portal vein thrombosis	Mar-Apr 2020	49	60 (23)	30/19		3
Salisbury (2020), UK [42]	ICU, GW	PTE, DVT	Mar 1-Apr 14, 2020	303	73	165/138	27	22
Shah (2020), UK [43]	ICU	PTE, DVT	Mar 15-May 05, 2020	187	57	124/63	28	64
Xu (2020), China [44]	ICU, GW	DVT	Jan 21-Feb 21, 2020	138	52.43 (16.7)	81/57		4
Yuriditsky (2020), US [45]	ICU	PTE, DVT	Apr 1-Apr 20, 2020	64	64	46/18		20
Bellmunt-Montoya (2021), Spain [46]	ICU	PTE, DVT	Apr 2020	230	61.8	177/53	30.3	61
Boyd (2021), Ireland [47]	ICU	PTE, DVT	Mar 1-Apr 5, 2020	38	57.9 (14.8)	28/10	25.7 (5.4)	5
Giannis (2021), US [48]	-	PTE, DVT	Mar 1-Apr 27, 2020	10,871				118
Gonzalez-Fajardo (2021), Spain [49]	-	PTE, DVT	Mar 1–Apr 30, 2020	2943	65			78
Gutierrez (2021), US [50]	-	VTE	-	4461	68	4163/298		412
Helms (2021), France [51]	ICU	PTE, DVT	Mar 3-May 30 2020	179	62	130/49	30	36
Lapébie (2021), France [52]	ICU	PTE, DVT	Mar 10-May 7, 2020	78	63.3 (13.9)	67/78	27.7 (4.4)	32
Lee (1) (2021), US [53]	-	PTE, DVT	Mar 20-May 3, 2020	220				47
Mattioli (2021), Italy [54]	-	PTE	Mar 15-Apr 27, 2020	105	73.7 (14.6)	61/44		1
Mu¯noz-Rivas (2021), Spain [55]	ICU, GW	PTE, DVT	Mar 3-May 3, 2020	1127				43
Planquette (2021), France [56]	-	PTE	Mar 1-Apr 20, 2020	1042				59
Vlachou (2021), UK [57]	ICU	PTE	Mar 23-Apr 5, 2020	39	62.3 (15)	22/17		18

Table 1 (continued)

Author, year, country(ref.)	Admit	VTE	Study period	Patients (*n*)	Mean age (SD)	Man/ woman	Mean BMI	VTE (*n*)
Valle (2021), Italy [58]	ICU, GW	PTE	Apr 8-May 26, 2020	114	61	84/30		65
Dujardin (2020), Netherlands [59]	ICU	PTE, DVT	Mar 13-Apr 9, 2020	127	62	98/29	27	53
Garcia-Ortega (2021), Spain [60]	ICU, GW	PTE	Mar 8–Apr 25, 2020	73.0	65.4	52/21	29.3 (5.8)	26
Chen (2021), China [61]	GW	DVT	11 June-8 July 2020	23	42.7 (12)	14/9	23.6 (2.8)	19
Hamadé (2021), France [62]	ICU, GW	PTE, DVT	Mar 2–Apr 11, 2020	46	67.2 (12)	22/24	27.9 (4.1)	10
Yi Guo (2020), China [63]	Non-ventilated	DVT	Jan25-Mar 04, 2020	121	64 (14)	62/59		58
Baccellieri (2020), Italy [64]	ICU, GW	DVT	Apr 2-Apr18, 2020	200	62	142/58	28	29
Chen (2020), China [65]	Mod. to severe	PTE	Jan and Feb 2020	25	65	15/10		10
Yu (2020), China [66]	ICU, GW	DVT	Dec 2019 and Apr 2020	142	61.9 (12.4)	81/61	23.5 (2.6)	50
Cai (2020), China [63]	Non-ventilated	DVT	25 Jan-4 Mar 2020	121	64 (14)	62/59		58
Ameri (2020), Italy [67]	Ventilated	PTE	Mar 1-Apr 9, 2020	689	67.3 (13.2)	487/202	27.2 (5.3)	52
Artifoni (2020), France [68]	GW	PTE, DVT	Mar 25-Apr 10, 2020	71	64	43/28	27.3	16
Hippensteel (2020), US [69]	ICU	PTE, DVT	Mar 18-Apr 14, 2020	101				24
Trigonis (2020), US [70]	Critically ill	DVT	Mar 31-Apr 13, 2020	45	60.8 (14.9)		33.6	19
Chen (2021), China [71]	ICU	DVT	Feb 1–Mar 20, 2020	88	63	54/34		40
Zhang (2020), China [72]	GW	DVT	Jan 29-Feb 29, 2020	143	63 (14)	74/69	23.6 (3)	66
Fauvel (2020), France [73]	ICU, GW	PTE	26 Feb-20 Apr 2020	1240	64 (17)	721/419	28.1 (6.3)	103
Benito (2020), Spain [74]	ICU, GW	PTE	Mar 9–Apr 15, 2020	76				32
Lerardi (2020), Italy [75]	Mod., severe, critical	DVT	Mar15-Apr 7, 2020	234	61.6 (14.2)	70/164	29.08 (5.1)	25
Middeldorp (2020), Netherlands [76]	ICU, GW	PTE, DVT	Mar 2 to Apr 12, 2020	198	61 (14)	130/68	27	39
Santoliquido (2020), Italy [77]	GW	DVT	3 and 10 Apr 2020	84	67.6 (13.5)	61/23		10
Kerbikov (2021), Russia [78]	Mod. to severe	DVT	First half of May 2020	75	63.4	36/39		15
Le Jeune (2020), France [79]	GW	DVT	Apr 8-May 12, 2020	42	64.6 (19.3)	23/19	28	8
Schiaffino (2021), Italy [80]	-	PTE	Mar 1-Apr 30, 2020	45	67	34/11		27
Melazzini (2020), Italy [81]	-	PTE, DVT	Mar 19-Apr 6, 2020	259	70	176/83		25
Mestre Gomez (2021), Spain [82]	Noncritically ill	PTE	Mar 30-Apr 12, 2020	452				29
De Cobelli (2021), Italy [83]	-	PTE	Mar 29–Apr 9, 2020	55	62	39/16	26	28
Kaminetzky (2020) [84]	-	PTE, DVT	Mar13-Apr 5, 2020	62	57.8	40/22		23
Demelo-Rodriguez (2020), Spain [85]	GW	DVT	First half of Apr 2020	156	68.1	102/54	26.9 (4.2)	23
Leonard-Lorant (2020), France [86]	ICU, GW	PTE	Mar 1–31, 2020	106				32
Nahum (2020), Germany [87]	ICU	DVT	Mar to Apr 2020	34	62.2 (8.6)	25/9	31.4 (9)	27
Ren (2020), China [88]	ICU	DVT	Feb 27-Mar 31, 2020	48	70	26/22		41
Grillet (2020), France [89]	ICU	PTE	Mar 15–Apr 14, 2020	100	66 (13)	70/30		23
Koleilat (2020), US [90]	-	DVT	Mar 1-Apr 10, 2020	135				18
Poyiadji (2020), US [91]	-	PTE	Mar 16-Apr 18, 2020	328				72
Taccone (2020), Belgium [92]	ICU	PTE	Mar 10, Apr 30, 2020	40	61	28/12		13

Table 1 (continued)

Author, year, country(ref.)	Admit	VTE	Study period	Patients (*n*)	Mean age (SD)	Man/ woman	Mean BMI	VTE (*n*)
Faggiano (2020), Italy [93]	GW	PTE	2020	25		21/4		7
Maatman (2020), US [94]	ICU	PTE, DVT	Mar 12 to Mar 31, 2020	109	61 (16)	62/47	34.8 (11.8)	31
Mouhat (2020), France [95]	ICU, GW	PTE	Mar 15–Apr 16, 2020	162	65.6 (13)	109/53		44
Pellens (2020), Belgium [96]	ICU	DVT	Mar 29th	12		9/3		8
Fang (2020), UK [97]	-	PTE	Mar 23–19 Apr, 2020	93				41
Contou (2020), France [98]	ICU	PTE	Mar 13-Apr 24, 2020	92	61	73/19		16
Ooi (2020), UK [99]	-	PTE	Mar 1-Apr 30, 2020	84				32
Rali (2020), US [100]	-	PTE, DVT	Apr 1 to Apr 27, 2020	147				25
Meiler (2020), Germany [101]	-	PTE, DVT	Mar 1-Apr 20, 2020	50	60.4 (10.1)	34/16		14
Ventura-Díaz (2020), Spain [102]	-	PTE	Mar 1–Apr 30, 2020	242	68	151/91		73
Longhitano (2020), Italy [103]	ICU, GW	PTE, DVT	18 and 31 May 2020	74	68.65 (15)	44/30		21
Cho (2020) US [104]	-	DVT	Mar 1, May 13, 2020	158	67.4 (14.6)	85/73	29.5 (7.5)	52
Whyte (2020), UK [105]	ICU, GW	PTE	Mar 3-May 7, 2020	214				80

Apr April, *BMI* body mass index, *Dec* December, *DVT* deep vein thrombosis, *Feb* February, *GW* general ward, *ICU* intensive care unit, *Jan* January, *Mar* March, *n* number, *PTE* pulmonary thromboembolism, *Ref.* = reference, *SD* standard deviation, *US* United States, *UK* United Kingdom, *VTE* venous thromboembolism

Based on the analysis by geographic region, racial differences and genetic factors can affect the occurrence of VTE in patients affected with Covid-19. A history of stroke and cerebrovascular events can be an influential risk factor.

Another meta-analysis study by Kefale B. et al. showed 33% prevalence of thrombotic events in patients with Covid-19 [106]. This investigation revealed that hospitalization in ICU, increased D-dimer levels, and mechanical ventilation are associated with a higher risk of developing thrombotic events. Another study showed that ICU patients were more likely than ward-hospitalized patients to experience major thromboembolism (17.2% versus 12.5%) [108]. This study showed that using a therapeutic dose of anticoagulant is more effective than a prophylactic dose in preventing VTE in all hospitalized patient.

Another meta-analysis study of Zhang R. et al. reported a 13% prevalence of VTE in non-ICU patients and 31% in ICU patients [109]. Severe underlying diseases, inactivity, senescence, and obesity have been reported as risk factors for VTE [110].

Several causes have been proposed to explain hypercoagulability in patients with Covid-19, including systemic inflammation, endothelial damage, and cytokine release that activate coagulation cascades [6, 111, 112]. Studies have shown that thrombosis occurs due to various biological pathways, including endothelial damage, macrophage/monocyte, and neutrophil activation. Researchers have found that prolonged immobility and the formation of antiphospholipid antibodies exacerbate thrombosis [113]. Another study that was conducted on patients undergoing extracorporeal membrane oxygenation (ECMO) showed that 50% of patients who have evidence of pulmonary ischemia do not have visible thrombus in the pulmonary artery. The possible cause of their pulmonary ischemia is immune-mediated microvascular thrombosis [114]. Studies have also investigated the laboratory parameters that indicate the increase in the incidence of VTE, which can be effective in selecting a therapeutic approach for these patients [115]. It is more likely that Covid-19 patients who have increased D-dimer and C-reactive protein (CRP) levels will develop VTE [116]. Fibrinogen level has been increased in hyper coagulopathy [117]. Fibrinogen and D-dimer levels are elevated in inflammatory conditions. Patients at risk for VTE may benefit from prophylactic anticoagulant therapy, and the appropriate anticoagulant should be determined. In a study, high doses of enoxaparin reduced mortality and incidence of VTE but were associated with a greater risk of major bleeding [118]. Another study showed that using a high dose of prophylactic anticoagulant in critically ill Covid-19 patients reduces the risk of thrombotic complications without an increase in the risk of bleeding [119]. It has been found that the risk of thrombosis and peripheral vascular disease in patients receiving moderate prophylactic or therapeutic doses of

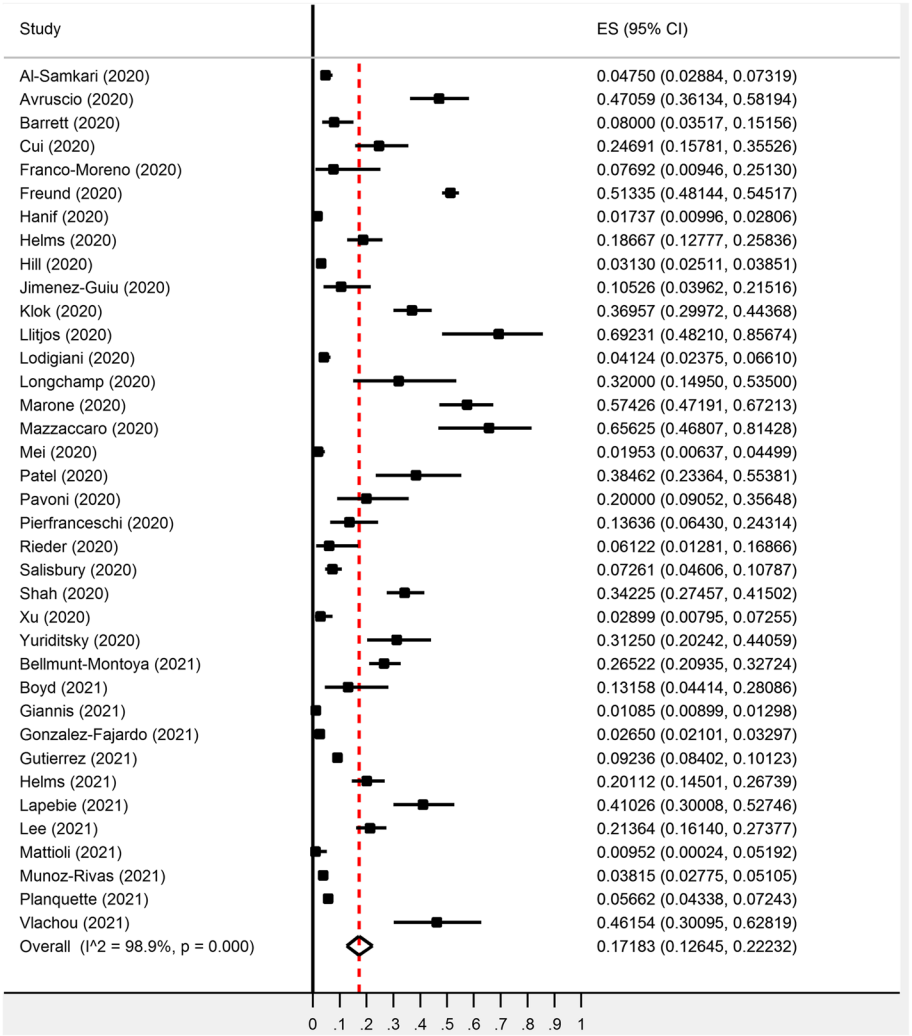

Fig. 2 Prevalence of VTE in patients with COVID-19

Table 2 Prevalence of VTE in Covid-19 patients in different geographical areas

Continent	Add of studies	Prevalence of VTE	*p*-value	Add of studies	*p*-value for heterogeneity
Asia	3	0.073 (95% *CI* = 0.003–0.21)	0.023	-	-
Australia	1	0.03 (95% *CI* = 0.025–0.04)	0.000	-	-
Europe	26	0.23 (95% *CI* = 0.15–0.32)	0.000	98.7	0.000
USA	8	0.093 (95% *CI* = 0.043–0.16)	0.000	98.9	0.000
Total	38	0.17 (95% *CI* = 0.13–0.22)	0.000	98.8	0.000

US Unites States, *VTE* venous thromboembolism

anticoagulants was similar to that of patients receiving standard prophylactic doses [120].

Studies have also reported an increased risk of arterial thromboses such as myocardial infarction, stroke, splenic infarction, splenic artery thrombosis, limb ischemia, and mesenteric ischemia in coronavirus-infected patients [121, 122]. There is an increased risk of cerebral venous sinus thrombosis in these patients, especially those with neurological symptoms [123].

In Covid-19 patients, various risk factors for VTE were investigated, and since patients were in different phases of the disease and it was not mentioned in the studies, it can

Table 3 Analysis of VTE risk factors in patients with COVID-19

Past medical history	Add of studies	OR(95%CI)	*P*-value	Heterogeneity		*p*-value for publication bias
				I^2	*p*-value	
Respiratory disease	27	1.11 (95% *CI* = 0.87–1.43)	0.4	0.0	0.51	0.014
Cardiovascular disease	35	1.17 (95% *CI* = 0.98–1.4)	0.086	0.0	0.55	0.069
Hypertension	34	0.92 (95% *CI* = 0.81–1.04)	0.195	24.8	0.097	0.068
Diabetes	35	0.98 (95% *CI* = 0.83–1.15)	0.76	36.6	0.017	0.008
Dyslipidemia	9	1.27 (95% *CI* = 0.96–1.68)	0.095	0.0	0.55	0.037
Immunodeficiency	3	0.52 (95% *CI* = 0.28–0.98)	0.043	60.7	0.08	0.654
Kidney disease	17	0.36 (95% *CI* = 0.26–0.5)	0.000	30.5	0.11	0.907
Liver disease	9	1.2 (95% *CI* = 0.56–2.6)	0.63	0.0	0.62	0.669
Malignancy	29	1.05 (95% *CI* = 0.82–1.36)	0.68	4	0.4	0.067
Smoking	19	1.02 (95% *CI* = 0.8–1.3)	0.84	35.3	0.06	0.059
Stroke	9	2.04 (95% *CI* = 1.09–3.8)	0.025	0.0	0.83	0.412

n number of studies assessed risk factor

affect the outcome. Additionally, VTE may be challenging to diagnose, especially in critically ill patients or those with low consciousness, and diagnostic measures may not be appropriate in some cases. Further studies are recommended to examine the risk factors in more details.

Conclusion

The current study showed a considerable prevalence of VTE in coronavirus-infected patients. According to variety in prevalences of VTE according to geographic areas, it showed that racial differences and genetic factors can affect the occurrence of VTE in these patients. In addition, a history of stroke and cerebrovascular accidents can be a serious risk factor, indicating the need for prophylactic anticoagulant treatment in these patients, but past medical history of respiratory disease, cardiovascular disease, hypertension, diabetes, dyslipidemia, liver disease, malignancy, and smoking is not risk factors of VTE in patients affected with Covid-19. We recommend further research into the underlying pathophysiology and risk factors involved.

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None

Authors' contributions
MS and ZT acquired the data. YS analyzed data. YS and ZT interpreted the data. MS and ZT drafted the manuscript; MS, YS, and ZT critically revised the manuscript for important intellectual content. MS supervised the study. All authors have read and approved the manuscript.

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Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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Abbreviations

VTE	Venous thromboembolism
ACE2	Angiotensin-converting enzyme2
MOOSE	Meta-analysis Of Observational Studies in Epidemiology
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
PTE	Pulmonary thromboembolism
MeSH	Medical Subject Headings
ISI	Institute for Scientific Information
SD	Standard deviation
BMI	Body mass index
NOS	Newcastle-Ottawa scale
RCT	Randomized controlled trial
ECMO	Extracorporeal membrane oxygenation
CRP	C-reactive protein

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