

Original Article



# Clinical Factors Associated with Deep Vein Thrombosis in Rehabilitation Patients Suspected of Thromboembolism after Cerebral Infarction

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## HIGHLIGHTS

- The purpose of this study is to investigate the association between characteristics of cerebral infarction lesion (vascular territory, etiology, and size), functional status and the occurrence of thromboembolism in patients with cerebral infarction.
- Female sex, middle cerebral artery infarction, and modified Rankin Scale score 5 could be potential risk factors for thromboembolism in rehabilitation patients after cerebral infarction.

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### Conflict of Interest

The authors have no potential conflicts of interest to disclose.

## ABSTRACT

The aim of this study is to investigate the association between characteristics of cerebral infarction lesion (vascular territory, etiology, and size), functional status and the occurrence of thromboembolism in patients suspected of having thromboembolism in a rehabilitation setting after cerebral infarction. Cerebral infarction patients who were suspected of having thromboembolism and who had undergone deep vein thrombosis (DVT) evaluation were included in analyses. Of the total 916 cerebral infarction patients, 65 patients were suspected of having DVT; 27 patients belonged to the DVT group and 38 patients belonged to the non-DVT group. The DVT (+) group was more likely to have a higher ratio of female, previous DVT history, middle cerebral artery (MCA) infarction, large arterial disease, modified Rankin Scale (mRS) score 5, abnormal speech and higher D-dimer. In multivariate logistic regression analysis, female sex, MCA infarction and mRS score 5 were significantly associated with the occurrence of thromboembolism in patients suspected of having thromboembolism. In contrast, other functional status, cerebral infarction etiology (Trial of ORG 10172 in Acute Stroke Treatment [TOAST] classification), and infarct volume were not associated with the occurrence of thromboembolism. In this study, female gender, MCA infarction, and mRS score 5 could be potential risk factors for thromboembolism in rehabilitation patients after cerebral infarction.

**Keywords:** Cerebral infarction; Venous thrombosis; Pulmonary embolism; Risk factors; Rehabilitation

## INTRODUCTION

Deep vein thrombosis (DVT) and pulmonary thromboembolism (PTE) are serious complications of stroke. They mostly develop within 2-weeks after stroke [1]. Although previous studies showed that incidence of DVT varied depending on method or time, it was expected to occur in 3%–8.6% of patients hospitalised with stroke [2]. One study reported that 4 of 96 Korean post-stroke rehabilitation inpatients (4.17%) were diagnosed with DVT [3]. DVT is an important issue in post-stroke care, because 26% of patients with untreated PTE have the possibility of a fatal medical condition [4].

There are various spectrums of DVT and PTE, from asymptomatic to cardiopulmonary dysfunction. Only a small percentage of patients with PTE report symptoms. Consequently, thromboembolism is often underdiagnosed, particularly in older patients after stroke. Early detection and prevention of thromboembolism are essential.

Most cases of DVT and PTE are identified by Doppler ultrasonography, contrast venography, lower extremity computed tomography (CT) and pulmonary embolism chest CT. Previous studies suggested that latex D-dimer assay could be used as a screening test for DVT and PTE [5]. Therefore, when patients are admitted for rehabilitation, we usually compare the calf circumference of both lower extremities. If there are symptoms, we identify D-dimer and then confirm using Doppler ultrasonography or CT for DVT or PTE diagnosis.

DVT risk factors have been extensively studied. According to the Center for Disease Control and Prevention (US Department of Health & Human Services), risk factors for DVT are immobilization (including paralysis), major surgery, pregnancy, hormone replacement therapy, cancer, congestive heart failure, lung disease, advanced age, obesity and others. Previous studies revealed that major risk factors for DVT/PTE were heart failure and altered level of consciousness [6]. Older age and immobilization are especially associated with high risk of thromboembolism [7]. Therefore, most of the patients in rehabilitation after cerebral infarction already have several risk factors for DVT and PTE.

However, most previous studies about risk factors of DVT have focused on medical problems of patients. Most patients admitted for rehabilitation after cerebral infarction are elderly and often experience paralysis, so it is necessary to identify clinical factors associated with thromboembolism according to their characteristics.

Several studies have tried to demonstrate the association between DVT, PTE and rehabilitation outcomes. One study found a significant association between DVT and lower extremity paresis, gait disturbance, severe calf muscle spasticity and ankle-foot orthosis (AFO) use [8]. Another study reported that no significant demographic or clinical factors for DVT were found [9]. However, studies about the relationship between brain lesion characteristics (vascular territory, etiology and infarction volume), functional status and the incidence of DVT or PTE were not enough. Therefore, this study aimed to 1) determine the association between the characteristics of cerebral infarction lesion (vascular territory location, etiology and size) and the occurrence of thromboembolism and 2) determine the association between functional status and the occurrence of thromboembolism in patients in rehabilitation setting after cerebral infarction suspected of having thromboembolism. We assumed that the location, etiology and size of cerebral infarction lesion may be associated with incidence of thromboembolism, because the symptoms of patients vary according to the location and size of lesions.

## MATERIALS AND METHODS

### Study design

This study was a retrospective, cross-sectional study of admissions to a single rehabilitation center after cerebral infarction over the 64-months from January 2012 to April 2017. All cerebral infarction diagnoses were confirmed by admitting neurologists, and we identified neuroimaging studies (magnetic resonance imaging [MRI]) acquired within 6 hours of

admission. Before we collected the data, this study obtained approval from the center's Institutional Review Board (Asan Medical Center, S2019-0277-0002).

### Participants

Patients who had a diagnosis of cerebral infarction were included in this study. The following were exclusion criteria: 1) diagnosis combined with other brain injury (traumatic brain injury, hemorrhage, hypoxic brain injury, brain tumors, meningoencephalitis etc.), 2) major surgery within 6-months of onset and bedridden state 3) DVT or PTE occurred during a period not related to cerebral infarction and 4) information could not be verified through medical records. Patients who were suspected of having thromboembolism and who underwent DVT evaluation were included in analyses.

### Thromboembolism diagnosis

On the basis of a previous study, we identified thromboembolism using the following process [10]. 1) clinical manifestations of suspected DVT or PTE (leg swelling, local tenderness, dyspnea, chest pain etc.), 2) elevation for latex D-dimer assay ( $\geq 0.5 \mu\text{g/mL}$ ) and 3) thrombus confirmed by venous ultrasonography or CT (lower extremity venography or pulmonary embolism chest CT).

### Stroke volume calculation

On the basis of a previous study, infarct volume was calculated by manually delineating areas of high signal intensity on axial diffusion-weighted imaging (DWI) image on MRI with a slice thickness of 5.0 mm [11]. Maximal surface of these areas was multiplied by the slice number [12]. We assumed that the infarct area was close to the sphere; therefore, infarct volume was calculated as  $1/4 \times$  maximal surface area of high signal intensity on axial DWI image  $\times$  slice number. Patients with embolic infarct for which it was difficult to identify maximal surface area were included in the analysis with an infarct volume of 0 mL.

### Data and outcome variables

Data of interest were related to risk factors of thromboembolism. Demographic variables included age, sex, hospital length of stay, body mass index (BMI) ( $\text{kg/m}^2$ ), stroke etiology (large arterial disease [LAD], small vessel disease or embolic), stroke location (anterior cerebral artery, middle cerebral artery [MCA], posterior cerebral artery, or undifferentiated), and comorbid conditions (heart failure, atrial fibrillation, cancer, diabetes mellitus, acute or chronic kidney disease, or previous thromboembolism history). Other lab data included C-reactive protein and D-dimer at the time of thromboembolism evaluation.

Clinically, patients diagnosed with LAD and MCA infarction were expected to show more severe disability [13]. Consequently, patients with LAD and MCA infarction were classified into the risk group and remaining patients were classified into low risk group for statistical analysis.

Rehabilitative evaluation data included mental status, extremity motor power of affected side, functional independence as measured by the modified Barthel index (MBI) score, modified Rankin Scale (mRS) and functional ambulatory category (FAC). The motor power of the patients was evaluated by the average of muscle strength on the affected side (hip, knee, and ankle) using the Medical Research Council grade. MBI was the outcome measures of activities of daily living (ADL) and ranged from 0 to 100. A higher score meant a higher degree of independence in basic ADL. mRS assessed the degree of disability or dependence. mRS score ranged from 0 to 6, with 0 meaning no symptoms and 6 meaning death. FAC

evaluated ambulation ability. This 6-point scale ranged from 0 to 5, with FAC 0 meaning patient could not walk, or needed help from 2 or more persons and FAC 5 meaning patient could independently walk. Other areas evaluated included speech and depression. Patients underwent depression evaluation by Hamilton depression rating scale, Beck depression index, State-Trait Anxiety Inventory and Geriatric Depression Scale depending on the patient's age and cognitive status.

We assumed that patients were at risk for the occurrence of thromboembolism if they were confirmed with abnormal mental status; trace or poor motor power in the lower extremity on the affected side; mRS score 5, which meant bedridden; FAC 0; depression; and abnormal speech such as cognitive communication disorder or aphasia. So, these patients were classified into the risk group, and the remaining patients were classified into the low risk group for statistical analysis.

All evaluations were performed by trained rehabilitation therapists within 48-hour of rehabilitation medicine department admission.

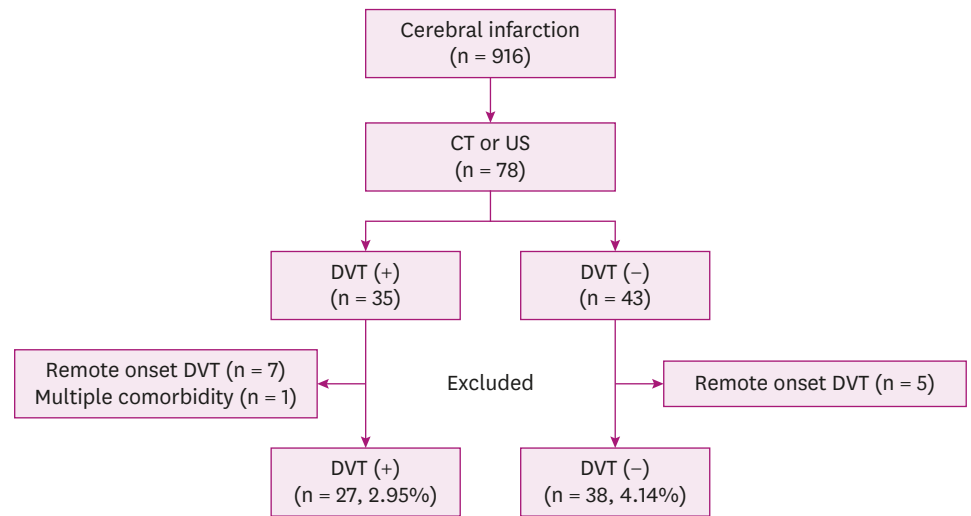
### Statistical analysis

All statistical analyses were performed using SPSS version 18.0 (IBM, New York, NY, USA). Among patients suspected of having thromboembolism who underwent US or CT evaluation, we divided patients into 2 groups: normal or negative evaluation (DVT (-) group) and those diagnosed with DVT or PTE (DVT (+) group). To determine whether there were clinical variables associated with occurrence of thromboembolism, we analyzed variables to reveal statistically significant differences between the 2 groups. For continuous variables, Mann-Whitney test was used for statistical analysis. For categorical variables, Fisher's exact test was used when frequency was < 5 and  $\chi^2$  test was used when frequency was  $\geq 5$ . For clinical variables with statistically significant differences between the groups, univariate logistic regression analysis and multivariate logistic regression analysis were used to ascertain how identified clinical variables were associated with occurrence of thromboembolism (0, absent; 1, present). Values of  $p < 0.05$  were considered statistically significant.

## RESULTS

Fig. 1 represents patient flow chart for this study. A total of 916 patients were evaluated from January 2012 to April 2017. DVT or PTE was suspected in 78 patients who underwent lower extremity CT venography or ultrasonography. Thirty-five patients were diagnosed with DVT or PTE (DVT (+) group), and 43 patients were negative (DVT (-) group). There were 7 patients in the DVT (+) group and 5 in the DVT (-) group diagnosed with thromboembolism during a period not related to cerebral infarction. One patient in the DVT (+) group had a history of hip fracture within 6-months. These patients were excluded from this study. Analysis included 27 patients (2.95%) in the DVT (+) group and 38 patients (4.14%) in the DVT (-) group were included in the analysis.

Table 1 represents differences in clinical variables between DVT (+) and DVT (-) groups. The DVT (+) group was more likely than the DVT (-) group to have higher ratio of female (85.19% vs. 39.47%;  $p < 0.01$ ), previous DVT history (11.11% vs. 0%;  $p = 0.04$ ), MCA infarction (64.71% vs. 34.21%;  $p < 0.01$ ), LAD (81.48% vs. 52.63%;  $p = 0.02$ ), mRS score 5 (51.85% vs. 18.42%;  $p < 0.01$ ), abnormal speech (92.59% vs. 34.21%;  $p = 0.02$ ), and higher D-dimer



**Fig. 1.** Patients flow chart. Initial screening included 916 patients, and 78 patients were suspected with thromboembolism and underwent lower extremity CT venography or US. Seven patients in the DVT (+) group and 5 patients in the DVT (-) group were diagnosed with thromboembolism during a period not related to cerebral infarction, and 1 patient in the DVT (+) group had comorbid disease, including a hip fracture. These patients were excluded from this study. CT, computed tomography; US, ultrasonography; DVT, deep vein thrombosis.

( $11.80 \pm 9.98$  vs.  $4.65 \pm 4.74$ ;  $p < 0.01$ ) (Table 1). The DVT (-) group was more likely than the DVT (+) group to have a higher ratio of heart failure (0% vs. 15.79%;  $p = 0.04$ ).

Logistic regression analyses were performed to determine whether there were clinical variables associated with occurrence of thromboembolism. Clinical variables with statistically significant differences between the DVT (+) group and the DVT (-) group were analyzed by logistic regression analyses. Table 2 represents univariate logistic regression analysis of clinical variables. Variables were correlated with the occurrence of thromboembolism: sex (female: odds ratio [OR], 8.81; 95% confidence interval [CI], 2.54–30.63), location (MCA infarction: OR, 8.46; 95% CI, 2.60–27.53), etiology (LAD: OR, 3.96; 95% CI, 1.24–12.65), mRS score 5 (OR, 4.77; 95% CI, 1.56–14.54), and abnormal speech (OR, 6.50; 95% CI, 1.33–31.83).

Table 3 represents multivariate logistic regression analysis of clinical variables. Because brain lesion location and etiology were variables that could be influenced by each other, brain lesion location and etiology were separately analyzed as variables of multivariate logistic regression analysis. Occurrence of thromboembolism was associated with sex (female), brain lesion location (MCA infarction) and mRS score 5. Brain lesion etiology and speech did not show statistically significant association with the occurrence of thromboembolism. Detailed ORs for the occurrence of thromboembolism are presented in Table 3.

## DISCUSSION

Our findings showed that the incidence of thromboembolism in rehabilitation patients after cerebral infarction was 2.95%. These results are similar to those of a previous study that reported the incidence of DVT was 2.4% [14].

**Table 1.** Differences in clinical variables between the DVT (+) and DVT (-) groups

Clinical variables	DVT (+) (n = 27)	DVT (-) (n = 38)	p value
Age (yr)	72.85 ± 10.66	73.42 ± 12.53	0.79
Sex			< 0.01*
Male	4	23	
Female	23	15	
Hospital days (day)	40.04 ± 15.19	65.26 ± 161.61	0.95
Heart failure	0	6	0.04*
Diabetes mellitus	5	14	0.17
Atrial fibrillation	14	12	0.13
Cancer	5	7	0.99
DVT history	3	0	0.04*
Kidney disease	3	6	0.72
CRP (mg/dL)	2.36 ± 3.12	3.27 ± 4.23	0.22
D-dimer (µg/mL)	11.80 ± 9.98	4.65 ± 4.74	< 0.01 <sup>†</sup>
BMI (kg/m <sup>2</sup> )	23.84 ± 2.55	23.22 ± 2.85	0.10
Brain lesion etiology			0.02 <sup>†</sup>
LAD	22	20	
Others	5	18	
Infarct volume (mL)	83.47 ± 100.36	103.81 ± 140.77	0.94
Mental status			0.08
Alert	17	32	
Others	10	6	
Motor power on the affected side			0.26
≥ Fair grade	7	15	
< Fair grade	20	23	
Depression			0.78
Normal	8	9	
Abnormal	19	29	
mRS			< 0.01 <sup>†</sup>
1–4	13	31	
5	14	7	
FAC			0.77
0	18	24	
1–4	9	14	
Speech			0.02*
Normal + dysarthria	2	25	
Abnormal	25	13	
MMSE	10.33 ± 9.01	13.11 ± 9.29	0.18
MBI	11.30 ± 17.25	11.87 ± 17.82	0.96
Brain lesion location			< 0.01 <sup>†</sup>
MCA	22	13	
Others	12	29	

Brain lesion location was separately analyzed, because there were patients with overlapping vascular territories. If a patient had MCA lesion with other lesions, he or she was included twice in the MCA group and in the other lesion group. Values are presented as mean ± standard deviation or numbers.

DVT, deep vein thrombosis; BMI, body mass index; CRP, C-reactive protein; LAD, large arterial disease; mRS, modified Rankin scale; FAC, functional ambulatory category; MMSE, Mini-Mental State Examination; MBI, modified Barthel index, MCA, middle cerebral artery.

\*p < 0.05, statistically significant by Fisher's exact test; <sup>†</sup>p < 0.05, statistically significant by  $\chi^2$  test; <sup>‡</sup>p < 0.05, statistically significant by Mann-Whitney test.

**Table 2.** Univariate logistic regression analysis of clinical variables associated with occurrence of thromboembolism

Clinical variables	Univariate logistic regression	
	OR (95% CI)	p value
Sex (female)	8.81 (2.54–30.63)	< 0.01*
Location (MCA)	8.46 (2.60–27.53)	< 0.01*
Etiology (LAD)	3.96 (1.24–12.65)	0.02*
mRS score 5	4.77 (1.56–14.54)	0.01*
Speech	6.50 (1.33–31.83)	0.02*

OR, odds ratio; CI, confidence interval; MCA, middle cerebral artery; LAD, large arterial disease; mRS, modified Rankin scale.

\*p < 0.05.



**Table 3.** Multivariate logistic regression analysis of clinical variables associated with thromboembolism

Clinical variables	Multivariate logistic regression			
	OR (95% CI)	p value	OR (95% CI)	p value
Sex (female)	10.37 (2.38–45.26)	< 0.01*	11.04 (2.55–47.80)	< 0.01*
Location (MCA)	4.94 (1.22–20.06)	0.03*	-	-
Etiology (LAD)	-	-	1.87 (0.49–7.10)	0.36
mRS score 5	3.71 (0.78–17.80)	0.10	6.12 (1.41–26.54)	0.02*

Sex, MCA infarction and mRS score 5 were associated with the occurrence of thromboembolism. mRS, modified Rankin scale; MCA, middle cerebral artery; OR, odds ratio; CI, confidence interval. \*p < 0.05.

Although screening for DVT during physical examination is known to identify calf swelling or difference in calf diameter [15], DVT is usually difficult to diagnose because clinical signs and symptoms are nonspecific. Therefore, for early detection and prevention of DVT or PTE, it is essential to identify which clinical factors are associated with thromboembolism and, in high-risk patients, perform screening tests such as latex D-dimer assay.

However, most previous studies about thromboembolism have focused on medical problems of patients. Studies about the relationship between brain lesion characteristics, functional status and the occurrence of thromboembolism were not enough.

To our knowledge, this is the first study to identify the relationship between cerebral infarction volume, vascular territory location and the occurrence of thromboembolism when patients are suspected of having thromboembolism. Also, we analyzed the relationship between brain lesion etiology (Trial of ORG 10172 in Acute Stroke Treatment [TOAST] classification), functional status and the occurrence of thromboembolism.

Several studies tried to identify the relationship between rehabilitative outcome and occurrence of DVT. Hara [8] studied the occurrence of DVT in 272 patients after cerebral infarction. In this study, DVT was diagnosed with multiple circumference measurements of thigh and calf, D-dimer and venous duplex US. DVT was diagnosed in 24 patients (8.8%). This study suggested that gait disturbance, severe calf muscle spasticity and use of AFO were significantly associated with the occurrence of DVT.

Stecker et al. [6] studied 2,613 patients with diagnosis of stroke about the occurrence of DVT and PTE. DVT or PTE was diagnosed in 33 patients (1.3%). In this study, 28 clinical factors including National Institutes of Health Stroke Scale, weakness, altered level of consciousness and aphasia were analyzed. The authors reported that altered level of consciousness and heart failure were the only factors associated with the occurrence of DVT or PTE.

Pongmoragot et al. [16] studied 11,287 patients with diagnosis of acute ischemic stroke regarding the occurrence of PTE. PTE was diagnosed in 89 patients (0.78%). Clinical factors including speech, weakness and stroke etiology were analyzed. This study suggested that there was no significant association between the incidence of PTE and speech, weakness and stroke etiology.

Our findings showed that sex difference (female), vascular territory (MCA infarction) and mRS score 5 were significantly associated with the occurrence of thromboembolism when patients were suspected of having thromboembolism. In contrast, other functional status, cerebral infarction etiology (TOAST classification), and infarct volume were not associated with the occurrence of thromboembolism.



In terms of sex difference, our findings during logistic regression analysis suggested that female patients were at higher risk for developing thromboembolism than male patients. In general, male patients were more likely to develop DVT. Roach et al. [17] reported that male patients had a higher risk of venous thrombosis than female patients. However, in this study, no significant differences were found between male and female gender except height. Furthermore, study populations were not focused on patients with cerebral infarction but on a heterogeneous general population. Liu et al. [18] studied risk factors for DVT in 862 patients with stroke. The authors reported that female patients experienced a higher risk of DVT (hazard ratio, 1.93; 95% CI, 1.19–3.14) than male patients.

In our study, we included a total of 530 male and 386 female patients. In contrast, the DVT (+) group included 4 male and 23 female patients. BMI, one of the risk factors of DVT, was significantly higher in women than in male. ( $22.66 \pm 2.56$  vs.  $24.06 \pm 2.72$ ,  $p < 0.01$ ) In conclusion, female patients were more likely to be exposed to risks of thromboembolism. Therefore, our findings suggest that female gender implies a higher risk of thromboembolism when patients are suspected of having thromboembolism in a cerebral infarction group. Further large-scale studies are needed to address this issue.

Our findings revealed that MCA infarction and mRS score 5 were significantly associated with the occurrence of thromboembolism when patients were suspected of having thromboembolism. Ng et al. [13] studied the relationship between clinical characteristics, functional outcomes and vascular territory in 2,213 patients with cerebral infarction. The authors reported that patients with MCA stroke showed the lowest Functional Independence Measure efficiency, which meant that the effectiveness of rehabilitation could be poor. Therefore, our findings suggested that patients with MCA infarction and mRS score 5 with bedridden status were more likely to have difficulty recovering ambulation because of reduced effectiveness of rehabilitation, which could increase the risk of thromboembolism.

There are several limitations of this study. First, patients included in analysis are limited to those who are suspected of having thromboembolism and undergo CT or US evaluation. We do not investigate all patients without thromboembolism. Therefore, the results of this study have limitations that should be applied to patients suspected of thromboembolism rather than whole cerebral infarction group. Second, heart failure is commonly known as a risk factor for thromboembolism. It is not present in the DVT (+) group but is included in the DVT (-) group as an opposite result. This result may be due to selection bias caused by small sample size included in analysis. Last, the sample size ( $n = 65$ ) is not sufficient to give a good prediction level in the regression model [19]. Therefore, further large-scale studies comparing thromboembolism and non-thromboembolism groups in patients with cerebral infarction patients will be necessary.

In conclusion, our study found that female gender, MCA infarction and mRS score 5 were significantly associated with the occurrence of thromboembolism when patients were suspected of having thromboembolism. Other rehabilitative evaluation outcomes, cerebral infarction etiology and infarct volume were not associated with the occurrence of thromboembolism. Therefore, female gender, MCA infarction and mRS score 5 could be potential risk factors for thromboembolism in rehabilitation patients after cerebral infarction. For this work, further large-scale studies that compare thromboembolism and non-thromboembolism groups in patients with cerebral infarction will be necessary.

## REFERENCES

1. Harvey RL. Prevention of venous thromboembolism after stroke. *Top Stroke Rehabil* 2003;10:61-69.  
[PUBMED](#) | [CROSSREF](#)
2. Douds GL, Hellkamp AS, Olson DM, Fonarow GC, Smith EE, Schwamm LH, Cockcroft KM. Venous thromboembolism in the Get With The Guidelines-Stroke acute ischemic stroke population: incidence and patterns of prophylaxis. *J Stroke Cerebrovasc Dis* 2014;23:123-129.  
[PUBMED](#) | [CROSSREF](#)
3. Han TR, Lim SJ, Lee HJ. Deep vein thrombosis in rehabilitation inpatients. *J Korean Acad Rehabil Med* 2001;25:827-835.
4. Qaseem A, Chou R, Humphrey LL, Starkey M, Shekelle P; Clinical Guidelines Committee of the American College of Physicians. Venous thromboembolism prophylaxis in hospitalized patients: a clinical practice guideline from the American College of Physicians. *Ann Intern Med* 2011;155:625-632.  
[PUBMED](#) | [CROSSREF](#)
5. Akman MN, Cetin N, Bayramoglu M, Isiklar I, Kilinc S. Value of the D-dimer test in diagnosing deep vein thrombosis in rehabilitation inpatients. *Arch Phys Med Rehabil* 2004;85:1091-1094.  
[PUBMED](#) | [CROSSREF](#)
6. Stecker M, Michel K, Antaky K, Cherian S, Koyfman F. Risk factors for DVT/PE in patients with stroke and intracranial hemorrhage. *Open Neurol J* 2014;8:1-6.  
[PUBMED](#) | [CROSSREF](#)
7. Rinde LB, Småbrekke B, Mathiesen EB, Løchen ML, Njølstad I, Hald EM, Wilsgaard T, Brækkan SK, Hansen JB. Ischemic stroke and risk of venous thromboembolism in the general population: the Tromsø study. *J Am Heart Assoc* 2016;5:e004311.  
[PUBMED](#) | [CROSSREF](#)
8. Hara Y. Deep venous thrombosis in stroke patients during rehabilitation phase. *Keio J Med* 2008;57:196-204.  
[PUBMED](#) | [CROSSREF](#)
9. Chua K, Kong KH, Chan SP. Prevalence and risk factors of asymptomatic lower extremity deep venous thrombosis in Asian neurorehabilitation admissions in Singapore. *Arch Phys Med Rehabil* 2008;89:2316-2323.  
[PUBMED](#) | [CROSSREF](#)
10. Mazzolai L, Aboyans V, Ageno W, Agnelli G, Alatri A, Bauersachs R, Brekelmans MP, Büller HR, Elias A, Farge D, Konstantinides S, Palareti G, Prandoni P, Righini M, Torbicki A, Vlachopoulos C, Brodmann M. Diagnosis and management of acute deep vein thrombosis: a joint consensus document from the European Society of Cardiology working groups of aorta and peripheral vascular diseases and pulmonary circulation and right ventricular function. *Eur Heart J* 2018;39:4208-4218.  
[PUBMED](#) | [CROSSREF](#)
11. Geurts M, Scheijmans FE, van Seeters T, Biessels GJ, Kappelle LJ, Velthuis BK, van der Worp HB; DUST investigators. Temporal profile of body temperature in acute ischemic stroke: relation to infarct size and outcome. *BMC Neurol* 2016;16:233-233.  
[PUBMED](#) | [CROSSREF](#)
12. van Seeters T, Biessels GJ, Kappelle LJ, van der Schaaf IC, Dankbaar JW, Horsch AD, Niesten JM, Luitse MJ, Majoie CB, Vos JA, Schonewille WJ, van Walderveen MA, Wermer MJ, Duijm LE, Keizer K, Bot JC, Visser MC, van der Lugt A, Dippel DW, Kesselring FO, Hofmeijer J, Lycklama À Nijeholt GJ, Boiten J, van Rooij WJ, de Kort PL, Roos YB, Meijer FJ, Pleiter CC, Mali WP, van der Graaf Y, Velthuis BK; Dutch acute stroke study (DUST) investigators. CT angiography and CT perfusion improve prediction of infarct volume in patients with anterior circulation stroke. *Neuroradiology* 2016;58:327-337.  
[PUBMED](#) | [CROSSREF](#)
13. Ng YS, Stein J, Ning M, Black-Schaffer RM. Comparison of clinical characteristics and functional outcomes of ischemic stroke in different vascular territories. *Stroke* 2007;38:2309-2314.  
[PUBMED](#) | [CROSSREF](#)
14. Ha SB, Choi KH, Kim CJ. The incidence of secondary poststroke complications in stroke patients in Korea as compared with those in western countries. *J Korean Acad Rehabil Med* 1999;23:485-491.
15. Goodacre S, Sutton AJ, Sampson FC. Meta-analysis: the value of clinical assessment in the diagnosis of deep venous thrombosis. *Ann Intern Med* 2005;143:129-139.  
[PUBMED](#) | [CROSSREF](#)
16. Pongmoragot J, Rabinstein AA, Nilanont Y, Swartz RH, Zhou L, Saposnik G; Investigators of Registry of Canadian Stroke Network (RCSN) and University of Toronto Stroke Program for Stroke Outcomes Research Canada (SORCan [www.sorcan.ca]) Working Group. Pulmonary embolism in ischemic stroke: clinical presentation, risk factors, and outcome. *J Am Heart Assoc* 2013;2:e000372.  
[PUBMED](#) | [CROSSREF](#)

17. Roach RE, Cannegieter SC, Lijfering WM. Differential risks in men and women for first and recurrent venous thrombosis: the role of genes and environment. *J Thromb Haemost* 2014;12:1593-1600.  
[PUBMED](#) | [CROSSREF](#)
18. Liu LP, Zheng HG, Wang DZ, Wang YL, Hussain M, Sun HX, Wang AX, Zhao XQ, Dong KH, Wang CX, He W, Ning B, Wang YJ. Risk assessment of deep-vein thrombosis after acute stroke: a prospective study using clinical factors. *CNS Neurosci Ther* 2014;20:403-410.  
[PUBMED](#) | [CROSSREF](#)
19. Knofczynski GT, Mundfrom D. Sample sizes when using multiple linear regression for prediction. *Educ Psychol Meas* 2008;68:431-442.  
[CROSSREF](#)