



## Venous Thromboembolism Following Abdominal Cancer Surgery in the Korean Population: Incidence and Validation of a Risk Assessment Model

Mi-hyeong Kim, MD, PhD<sup>1</sup>, Kang-woong Jun, MD<sup>1</sup>, Jeong-kye Hwang, MD, PhD<sup>1</sup>, Sang-dong Kim, MD, PhD<sup>1</sup>, Jang-yong Kim, MD, PhD<sup>1</sup>, Sun-cheol Park, MD, PhD<sup>1</sup>, Yong-sung Won, MD, PhD<sup>1</sup>, Sang-seop Yun, MD, PhD<sup>1</sup>, In-sung Moon, MD, PhD<sup>1</sup>, and Ji-il Kim, MD, PhD<sup>2</sup>

<sup>1</sup>Division of Vascular and Transplant Surgery, Department of Surgery, College of Medicine, The Catholic University of Korea, Seoul, Korea; <sup>2</sup>Division of Vascular and Transplant Surgery, Department of Surgery, Uijeongbu St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Uijeongbu-si, Gyeonggi-do, Korea

### ABSTRACT

**Background.** A cancer patient slated for abdominal surgery is considered to be at moderate to high risk for developing venous thromboembolism (VTE), but the incidence is quite low in Korean patients. Most risk assessment models and recommendations for VTE management are from Western reports, however they possibly overestimate the risk of VTE in the Korean population.

**Methods.** We retrospectively reviewed the medical records of 1966 patients who were diagnosed with abdominal organ cancer and required surgical treatment.

**Results.** Each patient was rated using the Caprini risk scoring model. The mean score was  $7.5 \pm 0.7$  points; 98.4% of patients were classified as high risk for VTE. Symptomatic VTE occurred in eight patients, and the overall incidence was 0.4%. The mean Caprini score for VTE patients was  $8.8 \pm 1.9$  points. In the group with scores between 5 and 9 points, the incidence was 0.3–0.5%, while in patients with scores  $> 10$  points, the incidence of VTE was found to be 1.12%.

**Conclusions.** The risk stratification system in the Caprini scoring model needs to be modified based on the actual incidence in the Korean population.

Abdominal organ surgery and the presence of malignancy are major risk factors for venous thromboembolism (VTE). Malignancy induces a hypercoagulable state by enhancing tissue factor exposure, producing cancer procoagulant, and promoting platelet activation and aggravation. Surgery contributes to VTE development by stimulating the hemostatic system and subendothelial tissue factor exposure.<sup>1–3</sup> Additional common conditions present in surgical cancer patients that affect VTE development include advanced age, an indwelling central venous catheter, or decreased mobility. The risk factors attributed to VTE development have been relatively well-identified in previous studies.

The Caprini risk scoring system is a representative VTE risk assessment model that is widely used throughout the world, including Asian countries.<sup>4–8</sup> However, the incidence of VTE was substantially lower in Asian patients than expected, even in moderate- to high-risk groups.<sup>8–14</sup> The correlation between racial difference and VTE incidence has been reported in several studies. According to nationwide database analyses, the VTE incidence from Western reports was 0.1–0.2% in the general population and 1.3–4% in cancer patients, whereas Asian reports had a much lower VTE incidence of 0.0088–0.013% in the general population and 0.2–0.67% in cancer patients.<sup>9–19</sup> White and Keenan compared VTE incidence among different ethnic groups living in California and found that the incidence was strikingly lower in the Asian group.<sup>20</sup>

Application of the Caprini risk scoring system without racial consideration can be problematic for Asian patients based on two aspects. First, it is possible to overestimate the risk of VTE and perform unnecessary anticoagulation

in Asian patients. Second, many Asian physicians do not follow recommended VTE prophylaxis using anticoagulation because mechanical prophylaxis is believed to be sufficient to prevent VTE in Asian patients. However, there is no consensus or consolidated report on the extent of VTE risk overestimation in Asian populations, or whether it is safe to deviate from the standard recommendations.<sup>21</sup> In this study, we assessed the incidence of VTE and the robustness of the Caprini risk scoring model in a Korean cancer patient cohort that was scheduled for abdominal surgery.

**METHODS**

*Patient and Data Selection*

We retrospectively reviewed the medical records of patients from two clinical departments (General Surgery and Gynecology) who were diagnosed with abdominal organ cancer and required surgical treatment between January 2013 and December 2014. We defined the criteria for patient selection (Fig. 1), and included all types of surgery if the primary lesion was resected, even if it was palliative surgery (grossly margin-positive resection or tumor reduction surgery). Surgeries conducted solely for biopsy or stage assessment were excluded from this study. A local tumor excision (via an endoscopic or transanal approach) performed in early-stage cancer without node metastasis was also excluded from this study. Surgeries for cancer recurrence or secondary cancer in patients already

diagnosed with, and treated for, primary abdominal organ cancer were not included.

We collected general medical information and specific data based on items from the Caprini risk scoring system (Fig. 2).<sup>4</sup>

1. *General Medical Information:* Age, sex, body mass index (BMI), past history (varicose veins, thrombophilia, deep vein thrombosis [DVT] or pulmonary thromboembolism [PTE], acute myocardial infarction, irritable bowel syndrome, lung disease, abortion, hormonal therapy), significant medical history within 1 month (admission, prior major surgery, congestive heart failure, sepsis, trauma, lung disease, cast, spinal cord injury, paralysis, stroke), family history of thrombosis, and laboratory findings evaluating coagulation status (protein C, protein S, lupus anticoagulant, homocysteinemia, anticardiolipin antibody, prothrombin 20210A mutation, Factor V Leiden mutation).
2. *Cancer-Related Information:* Cancer type, regional invasion, distant metastasis, resection margin (R0, R1, R2), cancer stage, patient survival, complications.
3. *Surgery-Related Information:* Hospital stay (preoperative and postoperative), operation time, type of surgery (laparotomy or laparoscopic approach), indwelling central venous catheter, stay in the intensive care unit, complications.
4. *Vte-Related Information:* Symptomatic VTE episode, VTE prophylaxis, diagnosis modality, treatment.

This study was approved by the Institutional Review Board of Seoul St. Mary’s Hospital (XC15RIMI0058).

**FIG. 1** Inclusion and exclusion criteria. Overall, 1966 patients were enrolled in the study after excluding 260 patients

Inclusion Criteria	Exclusion Criteria																				
<ul style="list-style-type: none"> <li>• Patients who were diagnosed with abdominal organ cancer and were awaiting surgery                             <ul style="list-style-type: none"> <li>- Curative major surgery</li> <li>- Palliative major surgery                                     <ul style="list-style-type: none"> <li>: R2 resection, tumor reduction</li> </ul> </li> </ul> </li> <li>• Cancer type                             <table border="1" style="margin-left: 20px; width: 100%; background-color: #fff9c4;"> <tr><td>Esophagus</td><td>Anus</td></tr> <tr><td>Stomach</td><td>Adrenal gland</td></tr> <tr><td>Duodenum</td><td>Endometrium</td></tr> <tr><td>Pancreas</td><td>Ovary</td></tr> <tr><td>Liver</td><td>Cervix</td></tr> <tr><td>Biliary tract</td><td></td></tr> <tr><td>Small bowel</td><td>Lymphoma</td></tr> <tr><td>Appendix</td><td>Sarcoma</td></tr> <tr><td>Colon</td><td>Neuroendocrine tumor</td></tr> <tr><td>Rectum</td><td></td></tr> </table> </li> </ul>	Esophagus	Anus	Stomach	Adrenal gland	Duodenum	Endometrium	Pancreas	Ovary	Liver	Cervix	Biliary tract		Small bowel	Lymphoma	Appendix	Sarcoma	Colon	Neuroendocrine tumor	Rectum		<ul style="list-style-type: none"> <li>• Age &lt; 18 (n=3)</li> <li>• Minor surgery (n=174*)                             <ul style="list-style-type: none"> <li>- Staging surgery</li> <li>- Surgery for biopsy</li> <li>- Local excision</li> </ul> </li> <li>• Primary tumor recurrence or previous another abdominal organ malignancy (n=122*)</li> <li>• Duration of follow-up &lt;6 months</li> </ul> <p style="font-size: small; margin-top: 10px;">* 39 patients fit both criteria 2 and 3</p>
Esophagus	Anus																				
Stomach	Adrenal gland																				
Duodenum	Endometrium																				
Pancreas	Ovary																				
Liver	Cervix																				
Biliary tract																					
Small bowel	Lymphoma																				
Appendix	Sarcoma																				
Colon	Neuroendocrine tumor																				
Rectum																					



**Joseph A. Caprini, MD, MS, FACS, RVT**  
*Louis W. Briegler Professor of Surgery.*  
 Northwestern University  
 The Feinberg School of Medicine;  
*Professor of Biomedical Engineering.*  
 Northwestern University;  
*Director of Surgical Research.*  
 Evanston Northwestern healthcare  
 Email: j-caprini@northwestern.edu  
 Website: venousdisease.com

# Thrombosis Risk Factor Assessment

Patients' Name: \_\_\_\_\_ Age: \_\_\_\_ Sex: \_\_\_\_ Wgt: \_\_\_\_ lbs

## Choose All That Apply

**Each Risk Factor Represents 1 Point**

- Age 41-60 years
- Minor surgery planned
- History of prior major surgery (< 1 month)
- Varicose veins
- History of inflammatory bowel disease
- Swollen legs (current)
- Obesity (BMI > 25)
- Acute myocardial infarction
- Congestive heart failure (< 1 month)
- Sepsis (< 1 month)
- Serious lung disease incl. pneumonia (< 1 month)
- Abnormal pulmonary function (COPD)
- Medical patient currently at bed rest
- Other risk factors \_\_\_\_\_

**Each Risk Factor Represents 2 Points**

- Age 60-74 years
- Arthroscopic surgery
- Malignancy (Present or previous)
- Major surgery (> 45 minutes)
- Laparoscopic surgery (> 45 minutes)
- Patient confined to bed (> 72 hours)
- Immobilizing plaster cast (< 1 month)
- Central venous access

**Each Risk Factor Represents 5 Points**

- Elective major lower extremity arthroplasty
- Hip, pelvis or leg fracture (< 1 month)
- Stroke (< 1 month)
- Multiple trauma (< 1 month)
- Acute spinal cord injury (paralysis)(< 1 month)

**Each Risk Factor Represents 3 Points**

- Age over 75 years
- History of DVT/PE
- Family history of thrombosis\***
- Positive Factor V Leiden
- Positive Prothrombin 20210A
- Elevated serum homocysteine
- Positive lupus anticoagulant
- Elevated anticardiolipin antibodies
- Heparin-induced thrombocytopenia (HIT)
- Other congenital or acquired thrombophilia

If yes:  
 Type \_\_\_\_\_  
**\*most frequently missed risk factor**

**For Women Only(Each Represents 1 Point)**

- Oral contraceptives or hormone replacement therapy
- Pregnancy or postpartum (< 1 month)
- History of unexplained stillborn infant, recurrent spontaneous abortion (≥3), premature birth with toxemia or growth-restricted infant

**Total Risk Factor Score**

**FIG. 2** Caprini risk scoring model. We retrospectively scored the VTE risk of all patients using this model. VTE venous thromboembolism, BMI body mass index, COPD chronic obstructive pulmonary disease, DVT deep vein thrombosis, PE pulmonary embolism

### Definition and Procedures

Symptomatic VTE that developed within 6 months after surgery was included. Symptomatic VTE indicated patient-reported symptoms such as limb swelling or dyspnea, and

confirmed DVT or PTE by duplex ultrasonography (DUS) for the upper or lower extremities, or computed tomography (CT) angiography for the upper and lower extremities or pulmonary arteries. DVT was defined as thrombosis in the iliac, femoral, popliteal, tibial, peroneal, or calf veins.

Thrombosis in the splanchnic or renal veins without any symptoms, and identified upon regular imaging evaluation, was excluded, as was any thrombosis that showed a possibility of having developed because of surgical manipulation (e.g. superior mesenteric vein thrombus after total pancreatectomy). On the upper extremity, radial, ulnar, brachial, axilla, subclavian or internal jugular veins, thrombosis was counted, with the exception of thrombosis that was obviously catheter-related. DUS was the preferred extremity DVT diagnosis modality, however CT angiography was selected when DUS was not sufficient due to severe limb swelling or if assessment of a proximal vein such as the iliac vein or inferior vena cava, subclavian vein, or superior vena cava, was needed. D-dimer was not included as a diagnostic criterion.

Mechanical prophylaxis was performed by either a single method or a combination of two methods: a gradual compression stocking with an ankle pressure of 20–30 mmHg, or a pneumatic compression device composed of three segmental compressors (ankle, calf, and thigh). Mechanical prophylaxis was started on the day of operation and maintained until the patient was ambulatory.

Pharmacological prophylaxis was performed using low molecular-weight heparin (1 mg/kg, once daily) based on the American College of Clinical Pharmacy (ACCP) guidelines.

### Analysis

This was a retrospective study, therefore we reviewed the preoperative medical records and rated the risk of VTE development using the Caprini risk scoring system. We also reviewed postoperative medical records to determine VTE development. Patients were categorized according to Caprini score, and VTE incidence was calculated for each group. Finally, we compared these results with those described in the 9th ACCP guidelines,<sup>22</sup> and compared the characteristics of all patients with those of VTE patients. VTE-related mortality was assessed by acquiring 3-month and overall mortality rates. The data are presented as mean  $\pm$  standard deviation or percentages.

## RESULTS

### *Venous Thromboembolism (VTE) Risk Assessment*

Overall, 2232 patients were included, 266 of whom were excluded based on the presented criteria (Fig. 1). Finally, 1966 patients were included and analyzed.

The mean age was 60 years, and 93% of patients received 1–3 additional points based on their age (Table 1). Sixty-two percent of patients had a history of central

venous catheter indwelling. In addition, there were also other risk factors, such as obesity, immobilization, recent medical problems, and past history.

Colorectal cancer (36%) and stomach cancer (32%) were common, and 11% of patients presented in the advanced stages, with regional invasion or distant metastasis (in 14 patients each) (Table 2). Laparotomy and laparoscopic surgery proportions were similar, with a mean operation time of approximately 4 h (Table 3).

We scored each patient using the Caprini risk scoring model. The mean score was  $7.5 \pm 0.7$  points; 98.4% of patients received more than 5 points, and were therefore classified as high risk for VTE development and required pharmacological prophylaxis (Fig. 3). However, in practice, 97% of patients underwent mechanical prophylaxis, while no patients received pharmacological prophylaxis (Fig. 4).

### *VTE Incidence and Characteristics*

Symptomatic VTE occurred in eight patients, and the overall incidence was 0.4%. We compared the characteristics of these eight VTE patients with those of the entire cohort of 1966 patients (Table 1). Among the VTE patients, female sex and advanced age were common. There was one colorectal cancer patient, three stomach cancer patients, and four ovarian cancer patients; regional invasion or distant metastasis were more common (four cases, 50%). Most of the surgeries were performed by laparotomy (75%) and had longer operation times (Table 3). In most cases, VTE was diagnosed within 1 month after surgery, but a delayed form of VTE was identified as late as 6 months after surgery (Table 4). Isolated calf vein thrombosis was the major type of VTE ( $n = 4$ ), but proximal vein involvement was observed in three patients (one popliteal VTE and two iliac VTEs). One patient with iliac vein thrombosis was also diagnosed with PTE, while another patient presented with isolated PTE without DVT.

The mean Caprini score was  $8.8 \pm 1.9$  points, which was more than 1 point higher than the mean score of the overall cohort of 1966 patients. We subanalyzed VTE incidence based on Caprini scores (Fig. 5). In the group with scores between 5 and 9 points, one or two cases of VTE developed, and the incidence was 0.3–0.5%, which corresponded to the incidence of the group with a low risk for VTE, according to the 9th ACCP guidelines. There was no obvious incidence discrepancy as the Caprini score increased. VTE did not develop in patients with scores lower than 5 points. On the contrary, in patients with scores  $> 10$  points, the incidence of VTE was found to be 1.12%, which was consistent with the moderate- to high-risk group based on the ACCP guidelines.

**TABLE 1** Preoperative general medical information from a total of 1966 patients and 8 VTE patients

	Total [N = 1966]	VTE [n = 8]
Male	1048 (53.3)	1 (12.5)
Age, years	60.7 ± 12.6 (18–91)	65.3 ± 11.1 (46–83)
≤ 40	130 (6.6)	0
41–60	828 (42.1)	3 (37.5)
61–74	711 (36.1)	4 (50)
≥ 75	297 (15.1)	1 (12.5)
BMI, kg/m <sup>2</sup>	23.59 ± 3.3 (15–44.7)	23.11 ± 4.0 (17.5–28.9)
> 25	612 (31.1)	2 (25)
Hospital stay, days	14 ± 10.3 (4–162)	21.6 ± 14.8 (5–49)
Postoperative	11 ± 8.9 (3–157)	18.3 ± 14.2 (5–46)
ICU ≥ 3 days	307 (15.6)	2 (25)
Central venous catheter	1227 (62.4)	6 (75)
Medical problem within 1 month <sup>a</sup>	25 (1.2)	1 (12.5)
Past history		
VTE	4 (0.2)	None
Myocardial infarction	21 (1)	None
Irritable bowel disease	2 (0.1)	None
Lung disease <sup>b</sup>	45 (2.25)	None
Caprini score	7.5 ± 0.7 (4–15)	8.8 ± 1.9 (5–11)

Categorical variables are expressed as *n* (%) and numerical variables are expressed as mean ± SD (range). VTE venous thromboembolism, BMI body mass index, ICU intensive care unit, SD standard deviation, COPD chronic obstructive pulmonary disease

<sup>a</sup>Any medical problem within 1 month prior to admission (prior admission for major surgery, congestive heart failure, sepsis, trauma, lung disease, cast, spinal cord injury, paralysis, or stroke, etc.)

<sup>b</sup>Abnormal pulmonary function (COPD), pneumonia

## Outcome

Seven of eight VTE patients received anticoagulation therapy for 3–6 months; the remaining patient did not receive anticoagulation because of the small thrombus burden and a tendency to bleed, but did receive serial imaging surveillance instead. The mean follow-up time was 24 months (range 17–35 months). No major or minor complications were associated with anticoagulation, and none of the patients presented with thrombus propagation or recurrence during follow-up. Only one of eight VTE patients expired 18 months after surgery due to pneumonia; there were no cases of VTE-related mortality.

## DISCUSSION

This study evaluated the incidence and characteristics of VTE after abdominal surgery in Korean cancer patients. We aimed to determine the consequences of insufficient prophylaxis and deviation from the standard recommendations for VTE prevention following surgery. We reached three conclusions. First, the Korean population exhibits a considerably low incidence of VTE compared with the Western population, and mechanical prophylaxis can be an

effective and safe method for VTE prevention. Second, patients with a Caprini risk score of 10 points or higher are definitely considered high risk for VTE development, and pharmacological prophylaxis must be considered. Third, the Caprini risk scoring system for patient risk stratification requires modification when applied to the Korean population.

We postulated that these findings may be associated with racial differences. Factor V Leiden mutation, resulting in hypercoagulation, has never been reported in the Korean population, and a relatively low prevalence of morbid obesity may contribute to the lower VTE incidence in the Korean population.<sup>23,24</sup> White and Keenan reported a racial difference in VTE development, even among subjects who lived in the same region.<sup>20</sup>

Although it occurs at a fairly low incidence, VTE is a definite problem in the Korean population. Based on a recent report, the incidence of VTE in the Korean population is on the rise, as are disease- and treatment-related costs, complications, and mortality.<sup>9,13,14</sup> Therefore, every patient should be evaluated for risk factors and be managed with the appropriate prophylaxis method. In our experience, items on the Caprini risk scoring system were clear, easy to check, and a relatively good fit for the Korean

**TABLE 2** Cancer-related information from a total of 1966 patients

	Total [N = 1966]	VTE [n = 8]
<b>Cancer type</b>		
Colon	717 (36.5)	1 (12.5)
Stomach	639 (32.5)	3 (37.5)
HCC	103 (5.2)	0
Biliary	102 (5.2)	0
Ovary	99 (5.0)	4 (50)
Endometrium	81 (4.1)	0
Cervix	69 (3.5)	0
Pancreas	56 (2.8)	0
Duodenum	23 (1.2)	0
Sarcoma	21 (1.0)	0
Lymphoma	19 (0.97)	0
Neuroendocrine tumor	16 (0.81)	0
Others	21 (1.0)	0
<b>Cancer stage<sup>a</sup></b>		
Localized	1751 (89.1)	4 (50)
Regional invasion	119 (6.1)	2 (25)
Distant metastasis	110 (5.6)	2 (25)
<b>Resectability</b>		
Curative resection	1920 (97.6)	7 (87.5)
Palliative resection	46 (23.4)	1

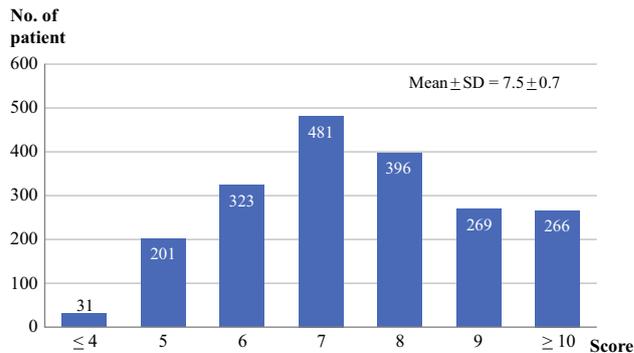
All variables are categorical and are presented as *n* (%)

VTE venous thromboembolism, HCC hepatocellular carcinoma

<sup>a</sup>Fourteen patients had both regional invasion and distant metastasis

population; however, we believe that the risk stratification system in the Caprini scoring system must be modified based on the actual incidence in the Korean population.

Based on our presented results, we verified that in patients with Caprini scores of 5–9 points, the real incidence of VTE was lower than 0.5%, and that this corresponded to a low risk for VTE. Thus, the Caprini risk scoring system and the 9th ACCP guidelines overestimate the real risk of VTE in the Korean population. We were



**FIG. 3** Patient distribution based on Caprini scores. More than 98% of patients received scores of more than 5 points based on the Caprini scoring system, which corresponds to high-risk for VTE development. *SD* standard deviation, *VTE* venous thromboembolism

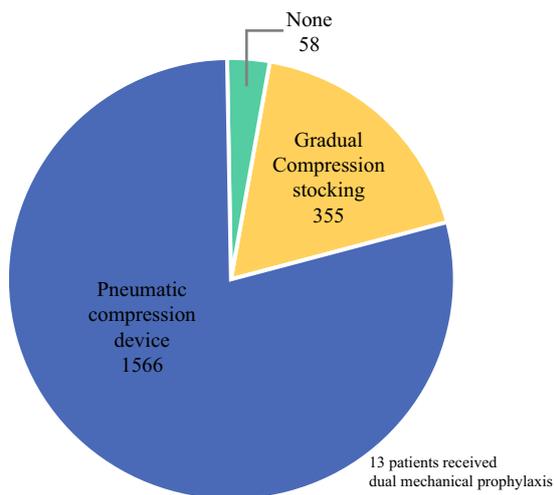
unable to assess incidence discrepancies among different scores, and believe that this could be associated with the small number of VTE episodes. There was a definite difference between the group with scores lower than 5 points and the group with scores higher than 10 points. No VTE occurred in patients with scores lower than 5 points, and a relatively high incidence (1.12%) was recorded in patients with scores higher than 10 points. According to the 9th ACCP guidelines and the references cited therein, the moderate-risk group is defined as exhibiting a VTE incidence of more than 1%, while the high-risk group is defined as exhibiting a VTE incidence of more than 1.9%. Therefore, Korean patients with more than 10 points have a moderate to high risk for VTE. We might conclude that most Korean surgical cancer patients would effectively prevent VTE by mechanical prophylaxis, but if the patient has obvious multiple risk factors and a score of more than 10 points based on the Caprini risk scoring system, he/she has to be considered for pharmacological prophylaxis.

However, definite conclusions cannot be drawn from this study due to limitations of a small sample size of only eight patients and the inability to obtain statistical significance. Therefore, we were not able to calculate *p*-values or

**TABLE 3** Surgery-related information from a total of 1966 patients and 8 VTE patients

	Total [N = 1966]	VTE [n = 8]
Laparotomy surgery	953 (48.5)	6 (75)
Operation time, min	237.8 ± 101.9 (70–1045)	281.6 ± 158 (165–580)
≤ 120	103 (5.2)	0
121–180	555 (28.2)	3 (37.5)
181–240	566 (28.8)	2 (25)
241–300	340 (17.3)	0
≥ 301	404 (20.5)	3 (37.5)

Categorical variables are expressed as *n* (%) and numerical variables are expressed as mean ± *SD* (range)  
VTE venous thromboembolism, *SD* standard deviation



\* None of the patients received pharmacological prophylaxis

**FIG. 4** Perioperative VTE prophylaxis methods. Ninety-seven percent of patients received mechanical prophylaxis for VTE prevention, and none of the patients received pharmacological prophylaxis. VTE venous thromboembolism

**TABLE 4** VTE-related information for 8 patients

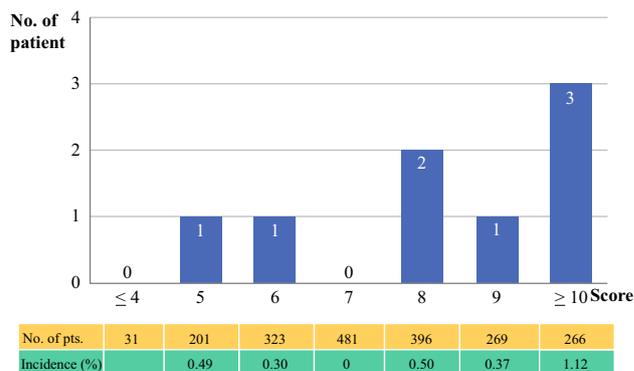
VTE prophylaxis	
None	1 (12.5)
Mechanical	7 (87.5)
VTE diagnosis, POD	
Within 1 month	6 (75)
1–3 months	1 (12.5)
3–6 months	1 (12.5)
VTE site	
Calf	4 (50)
Popliteal vein	1 (12.5)
External iliac vein	2 (25)
Pulmonary artery only	1 (12.5)

Categorical variables are expressed as *n* (%) and numerical variables are expressed as mean ± SD (range)

VTE venous thromboembolism, POD postoperative day

risk ratios. We plan to analyze more patients in order to increase the sample size and achieve statistical significance for further investigation.

In the current study, we evaluated the risk of VTE according to items on the Caprini risk scoring model; however, the effect of cancer type or stage for VTE development was not assessed. In the National Comprehensive Cancer Network and American Society of Clinical Oncology guidelines, cancer type and stage are very important risk factors for VTE development.<sup>25,26</sup> In the present study, compared with the overall group of 1966 patients, VTE was common in patients with stomach or ovarian cancer, as well as in those with advanced-stage



**FIG. 5** VTE incidence based on Caprini scores. Patients who scored between 5 and 9 points based on the Caprini risk scoring system had a VTE incidence of lower than 0.5%. With scores lower than 5 points, no VTE was observed, however with scores higher than 10 points, an increased incidence of more than 1% was observed. This corresponded to a moderate to high risk of VTE development. VTE venous thromboembolism

cancer. The eight VTE patients had advanced-stage cancer and underwent highly invasive surgery, and we predict that this could be associated with VTE development, but further investigation is required to reach this conclusion.

Another limitation of this study was its retrospective design. Information on coagulation factors, past history, family history, and physical examination was insufficient because an evaluation was not performed or was omitted when taking the patients’ history. As a result, the Caprini score could be underestimated in patients in this study.

In the present study, we aimed to assess the real risk of VTE and the necessity for pharmacologic prophylaxis in Asian patients who were relatively healthy and had recently performed casual activity with moderate to high levels of risk factors. We excluded patients who received minor surgery (operation time < 45 min based on the Caprini scoring system) because we did not consider this to be a major risk factor. In a patient who has undergone surgery due to cancer recurrence or secondary cancer development, he/she is already fragile and could have other factors increasing the risk of VTE, such as chemotherapy, radiotherapy, hormonal therapy, or decreased mobility, therefore we excluded these patients. Furthermore, we focused on VTE caused by systemic coagulopathy, and did not include specific thrombosis due to direct intimal injury (surgical manipulation or catheter-related).

Based on recent reports, the incidence of VTE in Asia is on the rise, which may be related to improved diagnosis and increased awareness of the disease.<sup>9,13,14</sup> The actual incidence of VTE in the Korean population may be higher than currently estimated. Careful risk assessment, identification of high-risk patients, and effective and proper prophylaxis to prevent VTE in the Korean population is necessary.

**ACKNOWLEDGMENT** The authors thank Kyung-Hye Kwon for assistance with the data collection.

**FUNDING** None.

**DISCLOSURE** Mi-hyeong Kim, Kang-woong Jun, Jeong-kye Hwang, Sang-dong Kim, Jang-yong Kim, Sun-cheol Park, Yong-sung Won, Sang-seop Yun, In-sung Moon, and Ji-il Kim have no conflicts of interest to declare.

## REFERENCES

- De Cicco M. The prothrombotic state in cancer: pathogenic mechanisms. *Crit Rev Oncol Hematol*. 2004;50:187–96.
- Fuentes HE, Tafur AJ, Caprini JA. Cancer-associated thrombosis. *Dis Mon*. 2016;62:121–58.
- Falanga A, Marchetti M, Vignoli A. Coagulation and cancer: biologic and clinical aspects. *J Thromb Haemost*. 2013;11:223–33.
- Caprini JA. Thrombosis risk assessment as a guide to quality patient care. *Dis Mon*. 2005;51:70–8.
- Bahl V, Hu HM, Henke PK, et al. A validation study of a retrospective venous thromboembolism risk scoring method. *Ann Surg*. 2010;251:344–50.
- Zhou HX, Peng LQ, Yan Y, et al. Validation of the caprini risk assessment model in Chinese hospitalized patients with venous thromboembolism. *Thromb Res*. 2012;130:735–40.
- Zhou H, Wang L, Wu X, et al. Validation of a venous thromboembolism risk assessment model in hospitalized Chinese patients: a case-control study. *J Atheroscler Thromb*. 2014;21:261–72.
- Liew NC, Alemany GV, Angchaisuksiri P, et al. Asian venous thromboembolism guidelines: updated recommendations for the prevention of venous thromboembolism. *Int Angiol*. 2017;36:1–20.
- Lee LH, Gallus A, Jindal R, et al. Incidence of venous thromboembolism in Asian populations: a systematic review. *Thromb Haemost*. 2017;117:2243–60.
- Jang MJ, Bang SM, Oh D. Incidence of venous thromboembolism in Korea: from the Health Insurance Review and Assessment Service database. *J Thromb Haemost*. 2011;9:85–91.
- Yhim HY, Jang MJ, Bang SM, et al. Incidence of venous thromboembolism following major surgery in Korea: from the Health Insurance Review and Assessment Service database. *J Thromb Haemost*. 2014;12:1035–43.
- Yu YB, Gau JP, Liu CY, et al. A nation-wide analysis of venous thromboembolism in 497,180 cancer patients with the development and validation of a risk-stratification scoring system. *Thromb Haemost*. 2012;108:225–35.
- Hong J, Lee JH, Yhim HY, et al. Incidence of venous thromboembolism in Korea from 2009 to 2013. *PLoS ONE*. 2018;13:e0191897.
- Law Y, Chan YC, Cheng SWK. Epidemiological updates of venous thromboembolism in a Chinese population. *Asian J Surg*. 2018;41:176–82.
- Chew HK, Wun T, Harvey D, et al. Incidence of venous thromboembolism and its effect on survival among patients with common cancers. *Arch Intern Med*. 2006;166:458–64.
- Hammond J, Kozma C, Hart JC, et al. Rates of venous thromboembolism among patients with major surgery for cancer. *Ann Surg Oncol*. 2011;18:3240–7.
- Heit JA. The epidemiology of venous thromboembolism in the community: implications for prevention and management. *J Thromb Thrombolysis*. 2006;21:23–9.
- Horsted F, West J, Grainge MJ. Risk of venous thromboembolism in patients with cancer: a systematic review and meta-analysis. *PLoS Med*. 2012;9:e1001275.
- Naess IA, Christiansen SC, Romundstad P, et al. Incidence and mortality of venous thrombosis: a population-based study. *J Thromb Haemost*. 2007;5:692–9.
- White RH, Keenan CR. Effects of race and ethnicity on the incidence of venous thromboembolism. *Thromb Res*. 2009;123 Suppl 4:S11–7.
- Parikh KC, Oh D, Sittipunt C, et al. Venous thromboembolism prophylaxis in medical ICU patients in Asia (VOICE Asia): a multicenter, observational, cross-sectional study. *Thromb Res*. 2012;129:e152–8.
- Gould MK, Garcia DA, Wren SM, et al. Prevention of VTE in nonorthopedic surgical patients: antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians evidence-based clinical practice guidelines. *Chest*. 2012;141:e227S–e77S.
- Klatsky AL, Armstrong MA, Poggi J. Risk of pulmonary embolism and or deep venous thrombosis in Asian-Americans. *Am J Cardiol*. 2000;85:1334–7.
- Ridker PM, Miletich JP, Hnnekens CH, et al. Ethnic distribution of factor V Leiden in 4047 men and women. Implications for venous thromboembolism screening. *JAMA*. 1997;277:1305–7.
- Lyman GH, Bohlke K, Khorana AA, et al. Venous thromboembolism prophylaxis and treatment in patients with cancer: American Society of Clinical Oncology clinical practice guideline update 2014. *J Clin Oncol*. 2015;33:654–6.
- Streiff MB, Holmstrom B, Ashrani A, et al. Cancer-associated venous thromboembolic disease, version 1.2015. *J Natl Compr Canc Netw*. 2015;13:1079–95.

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.