Assessment of thrombosis in right internal jugular vein after percutaneous superior vena cava catheter insertion during cardiovascular surgery with cardiopulmonary bypass

Chung-Sik Oh, MD, PhD,^a Ka Young Rhee, MD, PhD,^a Tae-Gyoon Yoon, MD, PhD,^a and Seong-Hyop Kim, MD, PhD^{a,b}

ABSTRACT

Objective: We evaluated the incidence of percutaneous superior vena cava catheter-related thrombosis and identified risk factors for developing the condition in patients undergoing cardiovascular surgery with cardiopulmonary bypass.

Methods: A total of 121 patients were evaluated. A percutaneous superior vena cava catheter was inserted into the right internal jugular vein during cardiovascular surgery with cardiopulmonary bypass. The right internal jugular vein was evaluated using ultrasonography, including cross-sectional area and velocity just before insertion of the percutaneous superior vena cava catheter (preoperative) and 24 hours and 48 hours after its insertion. If an echogenic mass was detected in the right internal jugular vein, the size was measured.

Results: The incidence of thrombosis in the right internal jugular vein was 56.2%. Change in the right internal jugular vein cross-sectional area and velocity had no clinical implications. Multiple logistic regression analysis identified age (odds ratio, 1.061; 95% confidence interval, 1.022-1.101; $P = .002$), superior vena cava catheter indwelling duration (odds ratio, 1.015; 95% confidence interval, 1.008-1.023; $P < .001$), and amount of transfusion platelet concentrate (odds ratio, 1.155; 95% confidence interval, 1.030-1.295; $P = .013$) as risk factors for percutaneous superior vena cava catheter-related thrombosis in the right internal jugular vein.

Conclusions: The incidence of percutaneous superior vena cava catheter-related thrombosis was higher than conventional central venous catheter-related thrombosis. Risk factors were age, superior vena cava catheter indwelling duration, and amount of transfusion platelet concentrate. (J Thorac Cardiovasc Surg 2016;152:1592-9)

Risk of thrombosis formation after SVC catheter insertion.

Central Message

The incidence of percutaneous SVC catheter-related thrombosis was 56.2%, and old age, long catheter indwelling duration, and transfusion were risk factors.

Perspective

The use of a percutaneous SVC catheter for CPB has increased recently, but catheter-related thrombosis has not been assessed. Our results reveal that the incidence of catheter-related thrombosis and risk factors are higher when a percutaneous SVC catheter is applied for CPB compared with those after the use of a conventional CVC.

See Editorial Commentary page 1600.

Evolving techniques and cosmetic concerns have resulted in the popularization of minimally invasive cardiovascular surgery with cardiopulmonary bypass (CPB). Essential

percutaneous vascular access points for CPB are used for most minimally invasive cardiovascular surgeries. A large-diameter percutaneous superior vena cava (SVC) catheter also has been applied during cardiovascular surgery with CPB to achieve better venous drainage of the CPB circulation.

From the ^aDepartment of Anesthesiology and Pain Medicine, Konkuk University Medical Center, and ^bResearch Institute of Medical Science, Konkuk University School of Medicine, Seoul, Korea.

This paper was supported by Konkuk University in 2015.

Trial Registry Number: KCT0000782 (<http://cris.nih.go.kr>).

Received for publication Dec 2, 2015; revisions received June 9, 2016; accepted for publication July 21, 2016; available ahead of print Sept 29, 2016.

Address for reprints: Seong-Hyop Kim, MD, PhD, Department of Anesthesiology and Pain Medicine, Konkuk University Medical Center, 120-1 Neungdong-ro, Gwangjin-gu, Seoul 05030, Republic of Korea (E-mail: yshkim75@daum.net).

0022-5223/\$36.00

Copyright © 2016 by The American Association for Thoracic Surgery

<http://dx.doi.org/10.1016/j.jtcvs.2016.07.071>

Scanning this QR code will take you to the article title page.

Abbreviations and Acronyms

aPTT	= activated partial thromboplastin time
BSA	= body surface area
CI	= confidence interval
CPB	= cardiopulmonary bypass
CSA	= cross-sectional area
CVC	= central venous catheter
CVP	= central venous pressure
DVT	= deep vein thrombosis
FFP	= fresh-frozen plasma
IJV	= internal jugular vein
INR	= international normalized ratio
OR	= odds ratio
PC	= platelet concentrate
pRBC	= packed red blood cell
PT	= prothrombin time
RIJV	= right internal jugular vein
SVC	= superior vena cava
USG	= ultrasonography

Damage to the vascular endothelium is inevitable when inserting a central venous catheter (CVC) and can induce thrombosis. Catheter-related thrombosis frequently leads to serious complications, such as deep vein thrombosis (DVT) or pulmonary thromboembolism.¹ The incidence of catheter-related thrombosis was 11.7% to 58% in retrospective reviews.^{2,3} However, many studies assessing catheter-related thrombosis investigated a small “conventional” CVC or peripherally inserted CVCs in patients with cancer, which are known to be more prothrombotic.⁴⁻⁸ A larger-diameter CVC leads to a higher rate of thrombosis, and a large-diameter venous cannula for extracorporeal membrane oxygenation can induce DVT.^{9,10} Thus, inserting a percutaneous SVC catheter could be associated with a high incidence of thrombosis. However, the incidence and risk factors for thrombosis in the right internal jugular vein (RIJV) after inserting a percutaneous SVC catheter have not been evaluated.

We hypothesized that a percutaneous SVC catheter would result in a higher incidence of catheter-related thrombosis than a conventional CVC. We evaluated the incidence of percutaneous SVC catheter-related thrombosis and identified the risk factors for developing the condition in patients undergoing cardiovascular surgery with CPB.

MATERIALS AND METHODS

Study Population

This study was approved by the Institutional Review Board (KUH1160055) of Konkuk University Medical Center, Seoul, Korea, and was registered at <http://cris.nih.go.kr> (KCT0000782). Patients undergoing cardiovascular surgery with CPB using a percutaneous SVC catheter in the RIJV were enrolled. Exclusion criteria were (1) contraindications for inserting a CVC in the RIJV, such as local neck

infection, distorted anatomy, coagulopathy, and previous radiation therapy on the neck; (2) preexisting CVC in the RIJV; and (3) any preexisting injury or echogenic mass in the RIJV. All data were collected by trained observers who did not participate in patient care and who were blinded to the study.

Central Venous Catheter Insertion

After inducing routine anesthesia, a percutaneous SVC catheter was inserted under ultrasonography (USG) guidance using the Seldinger technique. For accurate comparison of the RIJV USG value during preoperative and postoperative times, the patient was placed in a neutral position (not the Trendelenburg position) with the head turned maximally to the left side during insertion of the CVC. After preparing the skin with 0.1% chlorhexidine and sterile draping, a cardiac anesthesiologist evaluated the RIJV using a USG probe covered with an aseptic sleeve. A linear transducer (Vivid 7 Dimension, GE Vingmed Ultrasound System, Horten, Norway) was placed perpendicularly to the skin, and minimal pressure was applied to avoid deforming the RIJV. Optimal cross-sectional and longitudinal views of the RIJV were identified, and the RIJV was punctured using an 18-gauge steel needle attached to a 5-mL syringe. After confirming venous blood, the syringe was detached, and a guidewire was inserted. After removing the 18-gauge steel needle, 3 stepwise dilators (sizes were increased incrementally) were used to dilate the subcutaneous tissue and the RIJV.^{11,12} A percutaneous SVC catheter (DLP Femoral Arterial Cannulae; 21F, 7.0 mm external diameter and 17.8 cm usable length; Medtronic, Inc, Minneapolis, Minn) was inserted through the dilated entry into the RIJV. Immediately after percutaneously inserting the SVC catheter, approximately 20 mL of normal saline containing unfractionated heparin was injected to prevent acute thrombosis at the insertion site. The location of the catheter tip was confirmed by transesophageal echocardiography at the junction of the SVC and right atrium. The patient's head was turned maximally to the right side, and 2 types of CVCs were inserted into the left internal jugular vein (IJV) to infuse drugs and for hemodynamic monitoring. One was a CVC (Spectrum CVC; 7.0F and 20-cm usable length; Cook Medical Inc, Bloomington, Ind), and the other was a CVC with an introducer (AVA HF; 9.0F and 11-cm usable length; Edwards Lifesciences LLC, Irvine, Calif). A pulmonary artery catheter was inserted into the introducer to monitor pulmonary artery pressure. The percutaneous SVC catheter was removed 6 to 8 hours after admission to the intensive care unit to avoid catheter-related infections after confirmation of hemodynamic stability. The removal site was compressed manually using multiple-layered gauze for 20 minutes in all patients. After confirming the absence of additional oozing, a simple dressing was applied without further skin sutures.

Measurements

The USG evaluation of the RIJV was performed in all patients just before inserting the catheter (preoperatively) and 24 hours and 48 hours after insertion. The patient was placed in the same neutral position with the head turned maximally to the left side during the USG evaluation of the RIJV. Ventilation was halted briefly when the USG evaluation was performed to obtain optimal measurements. The USG evaluation of the RIJV included the maximal cross-sectional area (CSA) of the RIJV from the optimal cross-sectional view, venous flow velocity of the RIJV from the optimal longitudinal view, and maximal cross-sectional length of the echogenic mass if an echogenic mass was detected at 24 hours and 48 hours. The echogenic mass was considered a thrombosis related to the percutaneous SVC catheter when it was newly detected at 24 hours and had not been observed preoperatively. Central venous pressure (CVP) was measured immediately after inserting the pulmonary artery catheter and at 24 hours and 48 hours. The CVP measured immediately after inserting the catheter was considered CVP preoperatively. The CVPs at 24 hours and 48 hours were measured during the

USG evaluation. Coagulation profiles, including platelet count, prothrombin time (PT), international normalized ratio (INR), and activated partial thromboplastin time (aPTT) were checked preoperatively and at 24 hours and 48 hours. Preoperative medications relevant to coagulation, arrhythmia, percutaneous SVC catheter indwelling duration in the RIJIV, and total blood transfusion volumes while the percutaneous SVC catheter was indwelling were recorded.

Cardiopulmonary Bypass Regimen and Transfusion Protocol

After systemic heparinization (unfractionated heparin, 300 U/kg) and confirmation of an activated clotting time greater than 450 seconds, arterial catheterization (through the femoral artery) and inferior vena cava catheterization (through the femoral vein) were performed for CPB by the surgeon. Activated clotting time was measured using a whole blood coagulation system (Hemochron Response, Accriva Diagnostics, San Diego, Calif) and maintained for more than 450 seconds during CPB. After weaning the patient from CPB and confirmed de-airing, 1.5 mg protamine sulfate per 1 unit of unfractionated heparin was infused for 10 minutes to reverse the systemic heparinization.

Packed red blood cells (pRBCs) were transfused when hematocrit was less than 20% during CPB and less than 30% during the postoperative period. Two units of fresh-frozen plasma (FFP) were transfused when clotting time or rotational thromboelastometry clot formation time (ROTEM, TEM International, Munich, Germany) with the heparinized modified thromboelastometry test was beyond the normal range during the intraoperative period and INR was 1.5 to 2.0 (1 unit) or greater than 2.0 during the postoperative period. Eight units of platelet concentrate (PC) were transfused when maximal rotational thromboelastometry clot firmness was lower than the normal range during the intraoperative period or platelet count was less than 50,000/ μ L during the postoperative period. Ten units of cryoprecipitate were transfused when the fibrinogen level was less than 100 mg/dL during the intraoperative or postoperative period. The volumes of 1 unit of pRBC, FFP, PC, and cryoprecipitate at Konkuk University School of Medicine were 190 $\pm$ 20 mL, 150 mL, 50 $\pm$ 5 mL, and 40 $\pm$ 5 mL, respectively.

Statistics

Thrombosis in the RIJIV related to conventional CVC (7.0F, 20 cm length), as assessed by the USG evaluation, was 22% based on our

preliminary data with 10 patients undergoing cardiovascular surgery with CPB. The types of surgery included in the preliminary dataset were 4 aortic valvuloplasties and 6 mitral valvuloplasties. A sample size of 121 achieves 80% power to detect a difference using a 2-sided binomial test. The target significance level is .05. Differences in proportions were tested with the chi-square or Fisher exact test. Differences in means of the repeated measured continuous variables were tested using a mixed effect model by setting the patient to random effect, the time (from preoperatively to 48 hours) and thrombosis to fixed effect, and CSA and velocity of the RIJIV, platelet count, aPTT, PT, and INR to response variables. A univariate analysis for each potential risk factor of thrombosis formation was performed using logistic regression. Potential risk factors included age; gender; body surface area (BSA); underlying disease, such as hypertension, diabetes mellitus, and atrial fibrillation; perioperative coagulation-related medication, such as warfarin, aspirin, and clopidogrel; SVC catheter indwelling duration; and transfusion amount of pRBCs, FFP, PC, and cryoprecipitate. Factors for which the *P* value was less than .2 in the univariate analysis were subjected to a multivariate conditional logistic regression model using the backward stepwise regression procedure. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated on the basis of the final model. Continuous data are presented as means $\pm$ standard deviation or medians (interquartile range) according to the normal distribution. Data were analyzed using SPSS version 18.0 software (SPSS Inc, Chicago, Ill).

RESULTS

In total, 132 patients were eligible for the study. However, 11 were excluded for the following reasons: 2 for local neck infection, 1 for preoperative coagulopathy, and 8 for preexisting CVCs in the RIJIV. Thus, 121 patients were included in the study. Sixty-eight patients (56.2%) had a new echogenic mass in the RIJIV at 24 hours that was not observed preoperatively, and all echogenic masses lasted up to 48 hours. Demographic data and pRBC, PC, and cryoprecipitate transfusion volumes are shown in [Tables 1 and 2](#). All echogenic masses detected in the RIJIV were adherent to the venous wall ([Figure 1](#)). However, no echogenic mass

TABLE 1. Demographic data

	No thrombosis (N = 53)	Thrombosis (N = 68)	Total (N = 121)	<i>P</i> value
Age (y)	45 (35-57)	57 (44-65)	53 (39-63)	.003
Gender				.210
Male	28 (51%)	27 (49%)	55 (100%)	
Female	25 (38%)	41 (62%)	66 (100%)	
BSA (m ²)	1.73 (1.60-1.90)	1.64 (1.50-1.75)	1.68 (1.51-1.78)	.010
Underlying disease				
Hypertension	7 (37%)	12 (63%)	19 (100%)	.679
Diabetes mellitus	0 (0%)	13 (100%)	13 (100%)	.002
Atrial fibrillation	14 (37%)	24 (63%)	38 (100%)	.397
Preoperative coagulation-related medication				
Warfarin	12 (32%)	26 (68%)	38 (100%)	.102
Aspirin	7 (28%)	18 (72%)	25 (100%)	.118
Clopidogrel	3 (50%)	3 (50%)	6 (100%)	1.000
Intraoperative coagulation-related medication				
Heparin (unit)	18,900 (16,800-21,300)	17,400 (15,300-19,725)	18,300 (15,900-20,400)	.022
Protamine (mg)	251 (218-284)	224 (203-247)	235 (209-254)	.007

Data are expressed as median (25%-75%) or number of patients (percentile). BSA, Body surface area.

TABLE 2. Surgical characteristics

	No thrombosis (N = 53)	Thrombosis (N = 68)	Total (N = 121)	P value
Diagnosis and operation type				<.001
Right thoracotomy				
MVS	40 (60%)	27 (40%)	67 (100%)	
MS	7	5	12	
MR	33	22	55	
DVS	5 (38%)	8 (62%)	13 (100%)	
MR + TR	3	6	9	
MS + TR	2	2	4	
TVS	5 (21%)	19 (79%)	24 (100%)	
TR	5	19	24	
PVS	3 (100%)	0 (0%)	3 (100%)	
PR	3	0	3	
Left thoracotomy				
AAR	0 (0%)	6 (100%)	6 (100%)	
AD	0	6	6	
Sternotomy				
AVS	0 (0%)	8 (100%)	8 (100%)	
AR	0	8	8	
Anaesthesia time (min)	345 (285-389)	396 (330-480)	360 (315-430)	<.001
Operation time (min)	260 (205-295)	300 (255-390)	280 (235-350)	<.001
SVC catheter indwelling duration (min)	670 (615-715)	798 (733 -885)	725 (670-830)	<.001
Transfusion				
pRBCs (unit)	3 (1-4)	5 (4-6)	4 (2-6)	<.001
FFP (unit)	2 (2-3)	3 (2-4)	3 (2-4)	.086
PC (unit)	0 (0-8)	8 (8-12)	8 (0-8)	<.001
Cryoprecipitate (unit)	0 (0-0)	0 (0-8)	0 (0-0)	<.001

Data are expressed as number of patients (percentile) and median (25%-75%). Transfusion amount is the transfusion amount during percutaneous SVC catheter indwelling duration in the RIJV. MVS, Mitral valve surgery; MS, mitral stenosis; MR, mitral regurgitation; DVS, double valve surgery (including mitral and tricuspid valves); TR, tricuspid regurgitation; TVS, tricuspid valve surgery; PVS, pulmonary valve surgery; PR, pulmonary regurgitation; AAR, aortic arch repair (using graft interposition technique); AD, aortic dissection; AVS, aortic valve surgery; AR, aortic regurgitation; SVC, superior vena cava; pRBCs, packed red blood cells; FFP, fresh-frozen plasma; PC, platelet concentrate.

extended into the right atrium, and all were limited to inside the RIJV. The maximal cross-sectional lengths of the echogenic masses at 24 hours and 48 hours were 9.0 ± 4.7 mm and 8.8 ± 4.3 mm, respectively ($P = .550$). The CSA of the RIJV significantly decreased (estimate = -0.031 ; 95% CI, -0.060 to -0.002 ; $P = .036$), and the RIJV velocity significantly increased (estimate = 0.588 ; 95% CI, 0.024 - 1.152 ; $P = .041$) from preoperatively to 48 hours with linear changes (Figures 2 and 3). However, thrombosis did not show a significant association with the CSA and velocity of RIJV. Platelet count significantly decreased (estimate = -46.145 ; 95% CI, -50.236 to -42.054 ; $P < .001$), and aPTT significantly increased (estimate = 0.649 ; 95% CI, 0.157 - 1.141 ; $P = .010$) from preoperatively to 48 hours (Table 3). However, PT and INR did not change according to time, and thrombosis did not show a significant association with platelet count, PT, INR, and aPTT.

The univariate analysis identified male gender, age, BSA, warfarin medication history, SVC catheter indwelling duration, and transfusion amounts of pRBC, FFP, PC, and cryoprecipitate as risk factors. However,

multiple logistic regression analysis identified only age (OR, 1.061; 95% CI, 1.022-1.101; $P = .002$), SVC catheter indwelling duration (OR, 1.015; 95% CI, 1.008-1.023; $P < .001$), and transfusion amount of PC (OR, 1.155; 95% CI, 1.030-1.295; $P = .013$) as independent risk factors for percutaneous SVC catheter-related thrombosis in the RIJV (Table 4).

DISCUSSION

The incidence of percutaneous SVC catheter-related thrombosis was 56.2%, and age, SVC catheter indwelling duration, and PC transfusion were risk factors for percutaneous SVC catheter-related thrombosis.

Endothelial injury, intravascular stasis, and hypercoagulability are related to the formation of a thrombosis according to Virchow's triad theory. In the present study, the incidence of percutaneous SVC catheter-related thrombosis was higher than that of conventional CVC-related thrombosis in previous studies.^{2,13} The additional endothelial injury caused by inserting a SVC catheter compared with that after inserting a conventional CVC seems reasonable, because the external diameter of a

FIGURE 1. Ultrasonographic image of the thrombosis in the RIJV. A, Cross-sectional view. B, Longitudinal view. C, Venous flow velocity of RIJV from the optimal longitudinal view.

conventional CVC (7F) is approximately 3.3 mm, whereas that of a 21F percutaneous SVC catheter is 7 mm. This larger diameter and longer length than the conventional CVC would induce more mechanical irritation and damage to the vessel and increase the risk of forming a thrombosis.

Blood stasis did not seem to play a role in SVC catheter-related thrombosis. We assumed that a larger-diameter catheter could narrow CSA and disturb blood flow. A previous report also showed that CVC-related thrombosis is higher in the arm vasculature because of smaller vessel size than in the RIJV,¹⁴ indicating that a wider vessel is associated with better blood flow and a lower chance of forming a thrombosis. However, assessing the RIJV during indwelling of an SVC catheter by USG was impossible because a percutaneous SVC catheter was located in the RIJV in the present study. Therefore, we measured CSA and velocity in the RIJV preoperatively, after removing the SVC catheter, and 48 hours after inserting the catheter. Postoperative

CSA decreased significantly compared with preoperative values in the present study, which should have minimal effects on blood stasis because the difference was small. In addition, blood flow velocity in the RIJV was not different. These findings suggest that a large catheter has little effect on CSA or RIJV velocity after inserting or removing a catheter. Instead, CSA and RIJV velocity are influenced by several factors, such as hemodynamic changes or volume status, and the lack of a significant change in CVP supports this notion.

In a previous study, age was related to CVC-related thrombosis,^{2,15} consistent with the present results. Age is a well-known risk factor for thrombosis because of poor circulation, poorer venous valve function, and decreased physical activity.¹⁶

Percutaneous SVC catheter indwelling duration was an independent risk factor for thrombosis in the present study. In previous studies, the incidence of conventional CVC-related thrombosis also increased as indwelling duration

FIGURE 2. Change in CSA before and after percutaneous SVC catheter insertion. Preop is before percutaneous SVC catheter insertion, 24h is 24 hours after percutaneous SVC catheter insertion, and 48h is 48 hours after percutaneous SVC catheter insertion.

of the catheter increased.^{17,18} A direct comparison of thrombosis formation in both IJVs was not possible in the present study because conventional CVCs were kept in the left IJV for several days to continue drug administration and monitor CVP during the intensive care unit stay. However, mean indwelling duration of the CVC in the left IJV in our study was approximately 5 days,

which is shorter than in previous studies.^{17,18} Therefore, we infer that the incidence of conventional CVC-related thrombosis in our study might be less than in previous studies. Nevertheless, the incidence of thrombosis after inserting an SVC catheter was higher in the present study than in previous studies, as well as the absolute shorter catheter indwelling duration (<1 vs >5 days). This indicates that a

FIGURE 3. Change in velocity of RIJV before and after percutaneous SVC catheter insertion. Preop is before percutaneous SVC catheter insertion, 24h is 24 hours after percutaneous SVC catheter insertion, and 48h is 48 hours after percutaneous SVC catheter insertion.

TABLE 3. Coagulation profile change during perioperative period

	Preoperatively	24 h	48 h	<i>P</i> value
Platelet count $\times 10^3$ (μL)	204 $\pm$ 54	133 $\pm$ 54	112 $\pm$ 47	<.001
PT (sec)	15.0 $\pm$ 3.4	15.3 $\pm$ 1.0	15.1 $\pm$ 1.4	.838
INR	1.21 $\pm$ 0.36	1.22 $\pm$ 0.11	1.20 $\pm$ 0.14	.744
aPTT (sec)	37.8 $\pm$ 5.7	36.3 $\pm$ 4.2	39.1 $\pm$ 4.0	.010

Data are expressed as means $\pm$ standard deviations. Preoperatively is just before the insertion of the percutaneous SVC catheter, 24 h is 24 hours after insertion of the percutaneous SVC catheter, and 48 h is 48 hours after insertion of the percutaneous SVC catheter. *PT*, Prothrombin time; *INR*, international normalized ratio; *aPTT*, activated partial thromboplastin time.

large catheter strongly affected the formation of a thrombosis and suggests that SVC catheters should be removed early. Removing the SVC catheter early is associated with perioperative bleeding at the removal site in our clinical experience, which is why we removed the SVC catheter after confirming stable postoperative coagulation status. However, thrombosis can induce serious complications, such as DVT or pulmonary thromboembolism, and the SVC catheter should be removed early in the postoperative period to reduce perioperative catheter-related thrombosis.

PC transfusions affected the formation of thrombosis in the present study. Patients who received PC transfusions seemed to be at increased risk for DVT compared with those who did not.^{19,20} Platelet aggregation is the initial key step in the coagulation cascade. Thus, PC transfusions could promote and accelerate the coagulation cascade at a vessel damaged by a percutaneous SVC catheter.

The preoperative coagulation profile did not change substantially up to 48 hours postoperatively, except for the platelet count. Preoperative coagulation-related medication (warfarin, aspirin, or clopidogrel) was not related to the formation of a thrombosis in the present study. Bern and colleagues²¹ and Boraks and colleagues²² demonstrated that low-dose warfarin reduces catheter-related thrombosis. However, various coagulation-related medications, including heparin and protamine sulfate, were used during CPB, and coagulation factors were transfused in the present study. Thus, the coagulation system may have been affected more by the heparin and protamine sulfate than any preoperative coagulation-related

medications. Moreover, preoperative coagulation-related medication may not have a strong impact on the formation of a catheter-related thrombosis during cardiovascular surgery with CPB.

BSA was not a risk factor for thrombosis in the present study. Obesity was a risk factor for CVC-related thrombosis in previous studies.^{5,6} However, mean body weight and BSA were not high (63 ± 13 kg and 1.70 ± 0.21 cm^2 , respectively), and only a few obese patients were in our study population. Thus, the incidence of catheter-related thrombosis was not strongly associated with body weight or BSA in the present study.

Study Limitations

Several points should be taken into consideration in the present study. First, we could not directly compare the thrombosis formation in both IJVs because the indwelling duration of conventional CVCs in the left IJV was longer than that of the SVC catheter in the RIJV. However, it is assumed that the high incidence of thrombosis (56.2%) after SVC catheter insertion might be associated with the larger diameter and length of the SVC catheter than conventional CVCs in light of the short indwelling duration of the SVC catheter. Second, we did not manage thrombosis in the RIJV with thrombolytic agents because it was asymptomatic, and they increase the risk of postoperative bleeding. No definite guidelines exist for managing asymptomatic thrombosis, and no thrombosis-related complications occurred in the present study. However, patient safety could not be guaranteed by the absence of symptoms or a small thrombosis size. Previous studies reported that clinical thromboembolic events and CVC-related sepsis have occurred in asymptomatic patients.^{2,23} Because the incidence of percutaneous SVC catheter-related thrombosis was relatively high in the present study, a routine USG evaluation during insertion of a percutaneous SVC catheter is recommended to identify an asymptomatic thrombosis.

CONCLUSIONS

We observed a high incidence of percutaneous SVC catheter-related thrombosis in patients undergoing cardiovascular surgery with CPB. Age, SVC catheter indwelling duration, and transfusion amount of PC were independent risk factors for percutaneous SVC catheter-related thrombosis in the RIJV.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

References

1. Frizzelli R, Tortelli O, Di Comite V, Ghirardi R, Pinzi C, Scarduelli C. Deep venous thrombosis of the neck and pulmonary embolism in patients with a

TABLE 4. Multiple logistic regression for thrombosis formation after superior vena cava catheter insertion

	OR	95% CI	<i>P</i> value
Age	1.061	1.022-1.101	.002
SVC catheter indwelling duration	1.015	1.008-1.023	<.001
Transfusion amount of PC	1.155	1.030-1.295	.013

OR, Odds ratio; CI, confidence interval; SVC, superior vena cava; PC, platelet concentrate.

- central venous catheter admitted to cardiac rehabilitation after cardiac surgery: a prospective study of 815 patients. *Intern Emerg Med*. 2008;3:325-30.
2. Timsit JF, Farkas JC, Boyer JM, Martin JB, Misset B, Renaud B, et al. Central vein catheter-related thrombosis in intensive care patients: incidence, risks factors, and relationship with catheter-related sepsis. *Chest*. 1998;114:207-13.
 3. Trerotola SO, Stavropoulos SW, Mondschein JJ, Patel AA, Fishman N, Fuchs B, et al. Triple-lumen peripherally inserted central catheter in patients in the critical care unit: prospective evaluation. *Radiology*. 2010;256:312-20.
 4. Joks M, Czyz A, Poplawski D, Komarnicki M. Incidence and risk factors for central venous catheter-related thrombosis in hematological patients. *Med Oncol*. 2014;31:772.
 5. Chopra V, Anand S, Hickner A, Buist M, Rogers MA, Saint S, et al. Risk of venous thromboembolism associated with peripherally inserted central catheters: a systematic review and meta-analysis. *Lancet*. 2013;382:311-25.
 6. Maneval RE, Clemence BJ. Risk factors associated with catheter-related upper extremity deep vein thrombosis in patients with peripherally inserted central venous catheters: a prospective observational cohort study: part 2. *J Infus Nurs*. 2014;37:260-8.
 7. Lee AY, Levin MN, Butler G, Webb C, Costantini L, Gu C, et al. Incidence, risk factors, and outcomes of catheter-related thrombosis in adult patients with cancer. *J Clin Oncol*. 2006;24:1404-8.
 8. Gaitini D, Beck-Razi N, Haim N, Brenner B. Prevalence of upper extremity deep venous thrombosis diagnosed by color Doppler duplex sonography in cancer patients with central venous catheters. *J Ultrasound Med*. 2006;25:1297-303.
 9. Grove JR, Pevec WC. Venous thrombosis related to peripherally inserted central catheters. *J Vasc Interv Radiol*. 2000;11:837-40.
 10. Shafii AE, Brown CR, Murthy SC, Mason DP. High incidence of upper-extremity deep vein thrombosis with dual-lumen venovenous extracorporeal membrane oxygenation. *J Thorac Cardiovasc Surg*. 2012;144:988-9.
 11. Farrell EM. Percutaneous femoral bypass system: US Patent No 4,994,027; 1991.
 12. Sakai T, Gligor S, Diulus J, McAfee R, Wallis Marsh J, Planinsic RM. Insertion and management of percutaneous veno-venous bypass cannula for liver transplantation: a reference for transplant anesthesiologists. *Clin Transplant*. 2010;24:585-91.
 13. Lowell JA, Bothe A Jr. Venous access. Preoperative, operative, and postoperative dilemmas. *Surg Clin North Am*. 1991;71:1231-46.
 14. Tran H, Arellano M, Chamsuddin A, Flowers C, Heffner LT, Langston A, et al. Deep venous thromboses in patients with hematological malignancies after peripherally inserted central venous catheters. *Leuk Lymphoma*. 2010;51:1473-7.
 15. Gentile A, Petit L, Masson F, Cottenceau V, Bertrand-Barat J, Freyburger G, et al. Subclavian central venous catheter-related thrombosis in trauma patients: incidence, risk factors and influence of polyurethane type. *Crit Care*. 2013;17:R103.
 16. Van Stralen KJ, Doggen CJ, Lumley T, Cushman M, Folsom AR, Psaty BM, et al. The relationship between exercise and risk of venous thrombosis in elderly people. *J Am Geriatr Soc*. 2008;56:517-22.
 17. Pikwer A, Akeson J, Lindgren S. Complications associated with peripheral or central routes for central venous cannulation. *Anaesthesia*. 2012;67:65-71.
 18. Lobo BL, Vaidean G, Broyles J, Reaves AB, Shorr RI. Risk of venous thromboembolism in hospitalized patients with peripherally inserted central catheters. *J Hosp Med*. 2009;4:417-22.
 19. Cook D, Crowther M, Meade M, Rabbat C, Griffith L, Schiff D, et al. Deep venous thrombosis in medical-surgical critically ill patients: prevalence, incidence, and risk factors. *Crit Care Med*. 2005;33:1565-71.
 20. Wang TY, Sakamoto JT, Nayar G, Suresh V, Loriaux DB, Desai R, et al. Independent predictors of 30-day perioperative deep vein thrombosis in 1346 consecutive patients after spine surgery. *World Neurosurg*. 2015;84:1605-12.
 21. Bern MM, Lokich JJ, Wallach SR, Bothe A Jr, Benotti PN, Arkin CF, et al. Very low doses of warfarin can prevent thrombosis in central venous catheters. A randomized prospective trial. *Ann Intern Med*. 1990;112:423-8.
 22. Boraks P, Seale J, Price J, Bass G, Ethell M, Keeling D, et al. Prevention of central venous catheter associated thrombosis using minidose warfarin in patients with haematological malignancies. *Br J Haematol*. 1998;101:483-6.
 23. van Rooden CJ, Rosendaal FR, Barge RM, van Oostayen JA, van der Meer FJ, Meinders AE, et al. Central venous catheter related thrombosis in haematology patients and prediction of risk by screening with Doppler-ultrasound. *Br J Haematol*. 2003;123:507-12.

Key Words: central venous catheter, risk prediction, superior vena cava, thrombosis