Thrombosis Research 184 (2019) 38–43

Contents lists available at ScienceDirect

Thrombosis Research

journal homepage: www.elsevier.com/locate/thromres

Full Length Article

Thrombotic risk factors in patients with superior vena cava syndrome undergoing chemotherapy via femoral inserted central catheter

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ARTICLE INFO

Keywords:
Superior vena cava syndrome
Chemotherapy
Femoral inserted central catheter
Thrombosis
Risk factors

ABSTRACT

Objective: Our study aimed to scrutinize the incidence and risk factors of femoral inserted central catheter (FICC)-related thrombosis in patients with superior vena cava syndrome (SVCS) undergoing chemotherapy.
Methods: A retrospective analysis of patients with SVCS undergoing chemotherapy who received FICC catheterization at the Xiangya Hospital, Central South University, Changsha City, Hunan Province between May 2012 and February 2019 was performed. Both asymptomatic thrombosis and symptomatic thrombosis were diagnosed by color doppler ultrasound (CDUS). Univariate and multivariate logistic regression analyses were performed to identify patient-, insertion-, and catheter-related factors.
Results: Eight hundred and seventy-four patients with SVCS undergoing chemotherapy, with a total of 157,180 catheter days were enrolled in our study. FICC-related thrombosis was detected in 144 patients, and yielding an overall incidence of 16.47% or 0.92 events per 1000 catheter days. Of these, 19(2.17%) patients had symptomatic thrombosis. The mean time interval between FICC insertion and thrombosis onset was (10.40 ± 6.32) days and the mean catheter indwelling time was (179.84 ± 46.15) days. The history of deep venous thrombosis, treatment with vascular endothelial growth factor (VEGF) inhibitor (bevacizumab), puncture site (mid-thigh, groin), tip position and catheter size showed association with FICC-related thrombosis. Treatment with VEGF inhibitor [odds ratio (OR) = 2.779; 95%confidence interval (CI): 1.860–4.153; $P < 0.001$] and puncture site at the groin (OR = 10.843; 95%CI: 6.575–17.881; $P < 0.001$) were identified as independent risk factors of FICC-related thrombosis.
Conclusion: Treatment with VEGF inhibitor and puncture site at the groin during FICC catheterization were considered as high-risk factors in FICC-related thrombosis.

1. Introduction

Nowadays, peripherally inserted central catheter (PICC) has been widely used to obtain central venous access for both hospitalized and discharged patients [1–3]. The advantages of PICC are as follows: firstly, it is considered to be a safe and well acceptable method by patients with a preferable cost-efficiency ratio [4–7]; secondly, the PICC catheterization is minimally invasive and could be performed at patient's bedside, making it convenient for patients as well as providers [8–9]; thirdly, PICC could eliminate the pain [10] of patients by repeated puncturing, causing no hemothorax or pneumothorax [11]; and finally, it is easy to maintain. So, PICC is considered as in situ for longer time, with shorter length of hospital stay.

Superior vena cava syndrome (SVCS) is caused by the obstruction or compression of superior vena cava, leading to the edema of head, neck, and upper extremities, shortness of breath, and headaches [12]. The severity of these symptoms is associated with decreased venous return from the head, neck, and upper extremities, which in turn depends on the degree of superior vena cava stenosis [13]. This might be due to benign causes, but advanced lung cancer and malignant lymphoma are the most often causes in most of the patients. In general, such patients should avoid infusion from the veins of upper extremities, external jugular veins and subclavian veins as much as possible, but for patients with complete superior vena cava obstruction, infusion from the veins of lower extremities is the only choice [14]. However, patients with malignant tumors complicated with SVCS require multi-stage chemotherapy due to their critical condition [15]. So, femoral inserted central catheter (FICC) has become the preferred choice for venous access in patients with SVCS undergoing chemotherapy [16].

However, studies have shown that catheterization is a risk factor of

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https://doi.org/10.1016/j.thromres.2019.10.030
Received 29 June 2019; Received in revised form 14 October 2019; Accepted 31 October 2019
Available online 01 November 2019

thrombosis [17–18]. Current studies have largely focused on PICC-related upper extremity venous thrombosis, as well as on the incidence and independent risk factors of thrombosis, suggesting that they greatly differ. However, very little work has been focused on FICC-related thrombosis in patients with SVCS undergoing chemotherapy. Therefore, our study aimed to explore the incidence and risk factors of FICC-related thrombosis in patients with SVCS undergoing chemotherapy to provide a theoretical basis for clinical intervention and effective reduction of FICC-related thrombosis.

2. Methods

2.1. Study population

Our retrospective study enrolled patients who underwent FICC catheterization at the Xiangya Hospital, Central South University, Changsha City, Hunan Province from May 2012 to February 2019. This study was approved by the Hospital Ethics Committee and obtained informed consent from the patients. The catheters of all patients were maintained in the hospital during the period of hospitalization and discharge, and all patients were followed up. The patients who were diagnosed with SVCS by CT examination and received chemotherapy were included [15]. The Karnofsky Performance Status scores of all patients [19] were ≥70 points. The major organs such as liver, kidney, heart and bone marrow of the patients should function normally, and their coagulation function and blood routine tests were also normal. All patients were expected to survive for > 5 months. Moreover, all patients required to sign an informed consent form before undergoing FICC catheterization and a risk assessment notification.

The relevant exclusion criteria were as follows: patients with trauma or history of radiotherapy at the scheduled puncture site; vascular operation of the vein that should undergo cannulation; suspension of chemotherapy or < 4 chemotherapeutic cycles because of the pathogenetic condition; catheters maintained in other hospitals at discharge or patients who lost to follow-up; and patients who underwent unplanned extubation.

2.2. Diagnosis of FICC-related thrombosis

Routine examination of FICC-related thrombosis was performed by color doppler ultrasound (CDUS) 1 day before FICC catheterization, 7 days after FICC catheterization, and on day 1 of hospitalization in each chemotherapeutic cycle. After the progression of rational symptoms of thrombosis, i.e., lower extremities with swelling, pain or moving disorder when inserting the catheter, CDUS was used to detect the existence of thrombosis immediately.

CDUS was used to confirm the formation of thrombosis in patients with or without thromboembolic clinical symptoms. The CDUS diagnostic criteria of FICC-related thrombosis were as follows: 1) loss of compression of the imaging areas, i.e., the vein walls when the pressure is applied on the skin during real-time imaging; 2) visualization of echogenic material in the vein; 3) defect in the blood flow during color flow Doppler imaging; 4) loss or reduction of Doppler velocity spectrum changes; and 5) reduction or disappearance of pulsatility and variation with physiologic maneuvers such as rapid inspiration [20].

2.3. Data collection

All patients were identified from our safety infusion database. Sixteen potential risk factors of FICC-related thrombosis were collected. Patients-related potential risk factors included gender, age, history of deep venous thrombosis (DVT) and PICC, whether or not to undergo treatment with vascular endothelial growth factor (VEGF) inhibitor (bevacizumab) and combined with hypertension, diabetes, infection and catheter obstruction. Insertion-related potential risk factors included insertion side, puncture site (mid-thigh, groin), the time of puncture and tip position. Catheter-related potential risk factors included catheter brand and type, catheter size and catheter material. The patients were stratified according to the presence or absence of FICC-related thrombosis.

2.4. Statistical analysis

Descriptive statistics were used to evaluate study population and FICC-related thrombosis. All data were analyzed by using SPSS for Windows, Version 22.0 (SPSS Inc., IL, USA). The measurement data were expressed as mean ± standard deviation. Statistical description of enumeration data was expressed in terms of frequency and percentage. The differences in FICC-related thrombosis rate in different groups were evaluated by $\chi 2$ tests. Variables that are statistically significant and with a two-tailed $P < 0.05$, as well as those that could have clinical meaning based on the medical literature, were retained in the final multivariable model. Multivariate logistic regression analysis with Wald test method was used to estimate the unadjusted odds ratios (ORs) and 95% confidence intervals (CIs) for the association between all potential risk factors and FICC-related thrombosis.

3. Results

3.1. General population data

Eight hundred and seventy-four patients with SVCS undergoing chemotherapy, with a total of 157,180 catheter days were enrolled in our study. Among the 874 cases, 348 suffered from lung cancer (39.8%), 307 from malignant lymphoma (35.1%) and 219 had other diseases (25.1%). Among these, 647(74.0%) were men and 227(26.0%) were women, with an age range of 20–89 years [mean (57.73 ± 9.72) years], and 19.0% were older than 65 years. The mean catheter indwelling time was (179.84 ± 46.15) days.

3.2. The general situation of FICC-related thrombosis

Among the 874 patients, 144 patients developed FICC-related thrombosis, with an incidence of 16.47% and 0.92 per 1000 catheter days. These included 125 cases of asymptomatic thrombosis, with an incidence of 14.30%, and 19 cases of symptomatic thrombosis, with an incidence of 2.17%. The mean time interval between FICC insertion and thrombosis onset diagnosed by CDUS was (10.40 ± 6.32) days. The earliest thrombosis was formed on day 5 after catheter insertion, and a recent thrombosis after 90 days of FICC placement. There were 102 patients who developed thrombosis within 7 days after catheterization, which accounted for 70.8%, while 78.5% of patients within 14 days, and 98.6% of patients within one month.

3.3. Univariate analysis

Demographic and clinical characteristics of the patients are presented in Table 1. A statistically significant association was observed between FICC-related thrombosis and history of DVT, treatment with VEGF inhibitor (bevacizumab), puncture site (mid-thigh, groin), tip position and catheter size (a two-tailed $P < 0.05$). Gender, age, history of PICC, whether or not combined with hypertension, diabetes, infection, catheter obstruction, insertion side, the time of puncture, catheter brand and type and catheter material showed no significant association with FICC-related thrombosis (a two-tailed $P > 0.05$).

3.4. Multivariate logistic regression analysis (Table 2)

History of DVT, treatment with VEGF inhibitor (bevacizumab), puncture site (mid-thigh, groin), tip position and catheter size were analyzed by multivariate analysis. Treatment with VEGF inhibitor (OR = 2.779; 95%CI: 1.860–4.153; $P < 0.001$) and puncture site at

Table 1
Demographic and clinical characteristics.

Characteristic, n(%)	Patients without thrombosis (n = 730)	Patients with thrombosis (n = 144)	P value
Gender			0.965
Male	531(72.7%)	105(72.9%)	
Female	199(27.3%)	39(27.1%)	
Age			0.223
18–65 years old	604(82.7%)	113(78.5%)	
> 65 years old	126(17.3%)	31(21.5%)	
History of DVT			0.040
Yes	103(14.1%)	30(20.8%)	
No	627(85.9%)	114(79.2%)	
History of PICC			0.248
Yes	534(73.2%)	112(77.8%)	
No	196(26.8%)	32(22.2%)	
Treating with VEGF inhibitor(bevacizumab)			0.026
Yes	239(32.7%)	61(42.4%)	
No	491(67.3%)	83(57.6%)	
The merger with hypertension			0.402
Yes	312(42.7%)	67(46.5%)	
No	418(57.3%)	77(53.5%)	
The merger with diabetes			0.293
Yes	116(15.9%)	28(19.4%)	
No	614(84.1%)	116(80.6%)	
The merger with infection			0.211
Yes	71(9.7%)	19(13.2%)	
No	659(90.3%)	125(86.8%)	
The merger with catheter obstruction			0.190
Yes	57(7.8%)	16(11.1%)	
No	673(92.2%)	128(88.9%)	
Insertion side			0.516
Left	59(8.1%)	14(9.7%)	
Right	671(91.9%)	130(90.3%)	
Puncture site			0.019
Mid-thigh	447(61.2%)	73(50.7%)	
Groin	283(38.8%)	71(49.3%)	
The time of puncture			0.057
1	617(84.5%)	114(79.2%)	
2	88(12.1%)	19(13.2%)	
≥3	25(3.4%)	11(7.6%)	
Tip position			0.048
Optimal[a]	608(83.3%)	110(76.4%)	
Non-optimal	122(16.7%)	34(23.6%)	
Catheter brand and type			0.800
Bard, Groshong	65(8.9%)	12(8.3%)	
Bard, SOLO	123(16.8%)	29(20.1%)	
Bard, tolerant to high-pressure injection	272(37.3%)	50(34.7%)	
Medcomp, tolerant to high-pressure injection	270(37.0%)	53(36.8%)	
Catheter size			0.030
4Fr	480(65.8%)	81(56.3%)	
5Fr	250(34.2%)	63(43.8%)	
Catheter material			0.800
Silicone catheter	435(59.6%)	84(58.3%)	
Polyurethane catheter	295(40.4%)	60(41.7%)	

Abbreviations: DVT, deep vein thrombosis; PICC, peripherally inserted central catheter; VEGF, vascular endothelial growth factor.
[a] The optimal tip position of lower extremity catheterization was T8–10.

the groin (OR = 10.843; 95%CI: 6.575–17.881; $P < 0.001$) were identified as independent risk factors for FICC-related thrombosis.

4. Discussion

PICC is widely used in patients with malignant tumors undergoing chemotherapy. However, with the increasing incidence of malignant tumors, the incidence of SVCS is also gradually increasing. It is not suitable to insert PICCs from peripheral veins of upper extremities during the obstruction of superior vena cava, limiting its application and promotion of conventional PICC catheterization in these patients. To ensure the provision of chemotherapeutic drugs and other intravenous drugs in patients with SVCS to prolong their life span and improve their quality of life, FICC catheterization was performed. This has been proved effective during clinical verifications, expanding the scope of the application of PICC [16].

Table 2
Logistic regression analysis of risk factors associated with FICC-related thrombosis.

Variable	OR	95%CI	P-value
History of DVT	1.752	0.965–3.181	0.065
Treating with VEGF inhibitor (bevacizumab)	2.779	1.860–4.153	< 0.001
Puncture site at the groin	10.843	6.575–17.881	< 0.001
Non-optimal tip position	1.713	0.985–2.981	0.057

Abbreviations: FICC, femorally inserted central catheter; OR, odds ratio; CI, confidence interval; DVT, deep vein thrombosis; VEGF, vascular endothelial growth factor.

The incidence of FICC-related thrombosis in patients with SVCS undergoing chemotherapy was 16.48% in our study, which was consistent with the reported literature in this population [16]. But it was higher than that in non-cancer patients [21–23], and this is because the malignant tumors could induce blood hypercoagulable state, increasing the risk of thrombosis [24]. Several studies [20,25] have found that the incidence of symptomatic FICC-related thrombosis was 1%–25.7%, while the incidence of asymptomatic thrombosis was as high as 25.2%–71.9%. The reported incidence of FICC-related thrombosis varied greatly. It is speculated that the possible causes might be due to study population (cancer patients or general patients), study design (prospective or retrospective) and screening population (only symptomatic or all). The incidence of symptomatic FICC-related thrombosis in our study was 2.17%, which was in accordance with the published data [26]. And the incidence of asymptomatic FICC-related thrombosis in our study was 14.30%. The main reasons for a lower asymptomatic FICC-related thrombosis incidence in our study might be due to retrospective design and also we did not consider the administration of anticoagulant drugs in some patients with SVCS who were at high risk of developing FICC-related thrombosis. In addition, our study found that 70.8% of FICC-related thrombosis occurred within 7 days after catheterization, which was consistent with Walshe LJ et al. [27] study. And 98.6% of FICC-related thrombosis occurred within one month after catheterization in our study. Early occurrence of thrombosis is mainly related to repeated punctures, which in turn leads to injury of vascular endothelium, while the thrombosis developed after week one was caused due to inadequate and incorrect methods of limb functional exercises. Therefore, attention should be paid regarding the occurrence of FICC-related thrombosis within one month after catheterization, especially in the first week after catheterization, and also supervise and urge patients to undergo standard limb functional exercises as early as possible. This, in turn, could effectively reduce the occurrence of FICC-related thrombosis.

No significant association between FICC-related thrombotic risk and advanced age was found in our study, although whether the patients' age affects the occurrence of thrombosis is currently controversial. In the study conducted by Kang JR et al. [28], among patients with chemotherapy who underwent catheterization, the results of stratified analysis showed no significant relationship between thrombosis risk and advanced age, which was consistent with the results of our study. This might be due to the use of chemotherapeutic drugs by patients. However, some scholars [23] believed that women of childbearing age were more prone to thrombosis, while the incidence of thrombosis was higher in men after age 55, and this might be due to the changes in circulating reproductive hormone in vivo. A population-based cohort study of all residents of Olmsted County, MN, in 1981–2010 found that

the overall thrombosis incidence was increased with increasing age of the patients in both sexes [29]. And Nicholas J et al. [30] also considered advanced age as a risk factor of thrombosis.

Our study results showed a significance in cases with history of DVT in the FICC-related thrombosis group (20.8%) than those in the non-FICC-related thrombosis group (14.1%), suggesting the association of history of DVT with FICC-related thrombosis. But this did not conclude history of DVT as an independent risk factor of FICC-related thrombosis. The relationship between history of DVT and FICC-related thrombosis still remained uncertain. According to a study [31], patients who received catheterization with a history of DVT more likely had symptomatic thrombosis. Some scholars [32] used data from the medical records and contemporary modeling techniques to identify the risk factors associated with thrombosis, and the factors included history of DVT. So, the Caprini risk assessment scale, which is widely used to estimate the risk of venous thromboembolism in hospitalized patients, revealed a greater association of history of DVT when estimating the risk of thrombosis [32]. All the above studies revealed that history of DVT was associated with increased thrombotic risk [33]. Also it has been reported that [34] although both personal and family histories of thrombosis were included as risk-assessment items in some scales, no significant relationship between thrombotic risk and these parameters were observed in the current study.

Bevacizumab (Avastin®) is a humanized mAb that targets VEGF and showed its benefits in the treatment of malignant tumors [35]. Bevacizumab, when combined with chemotherapy, improved the survival rate of patients with malignant tumors [36]. However, treatment with bevacizumab is associated with increased risk of thrombosis [37–38]. Consistent with the above researches, our study proved treatment with bevacizumab as an independent risk factor of FICC-related thrombosis. At present, the mechanisms for thrombosis in the setting of bevacizumab therapy are poorly understood. Kiuru M et al. [39] believed that it is a multifactorial disease and might include direct endothelial cell injury, production of endothelial nitric oxide, increased platelet aggregation and activation of FcγRIIa platelet receptors. According to the results of Rollin J et al., platelet aggregation led to thrombocytopenia, blood hypercoagulable state and thrombosis in susceptible patients, and the effect of it depends on FcγRIIa platelet receptors [40]. Other studies indicated that complex formation with VEGF and activation of FcγRIIa platelet receptors led to platelet aggregation and granule release, subsequently developing thrombosis [41–42]. In addition, some scholars believed antithrombin deficiency as a major risk factor of thrombosis [43]. So, it is assumed that increased thrombin activation and thrombocytosis induced by chemotherapy might play a synergistic role in causing thrombotic diathesis [41]. While other studies considered it to be related to the reduction of endothelial cells caused by bevacizumab [39], which requires replenishing dying endothelial cells for triggering thrombotic events. Therefore, it is necessary to carefully balance the benefits against the risks that the chemotherapy regimens with bevacizumab would bring in.

There were no significant differences in the incidence of thrombosis between FICC insertion by left and right femoral veins. As we all know, the femoral vein is passed into the vena iliaca externa at the inguinal ligament level, forming the common iliac vein with the internal iliac vein at the sacroiliac joint level. And the bilateral common iliac veins merge into the inferior vena cava at the fifth lumbar vertebra. The right common iliac vein almost straightly turns into the inferior vena cava, facilitating cannulation at this location. But the left common iliac vein intersects with the inferior vena cava almost in straight angle, where it becomes difficult to catheterize and prone to fold backward. Additionally, both the right arteria iliaca communis and the left internal iliac artery cross in front of the left arteria iliaca communis, so that the left common iliac is constricted in two places at the same time. Because of the long-term constriction and the mechanical forces produced by pulsation, the FICC insertion into the left femoral vein more likely progresses to FICC-related thrombosis. We can conclude that the preferred access approach for FICC placement is the right femoral vein. According to a study, a higher incidence of thrombosis was observed after FICC insertion by the left femoral vein when compared with the right femoral vein [44]. But why did our study show no differences between the left and right sides? This is because among the 874 patients enrolled in our study, 801 patients underwent FICC catheterization on the right, and only 73 patients underwent FICC catheterization on the left due to trauma, hemiplegia and DVT of the right lower extremity. The sample size subjected to left femoral vein catheterization was relatively small, warranting a study with a larger patient population, which permits for a more precise assessment.

Our study showed that puncture site at the groin during FICC catheterization was an independent risk factor of FICC-related thrombosis when compared with that at mid-thigh. Some scholars have also confirmed that the incidence of FICC-related thrombosis is higher when the puncture site is located at the groin than at mid-thigh [16]. The groin region is more prone to be contaminated by perspiration and excreta due to its proximity to the perineum, making it difficult to clean. Because of the wrinkled and hairy skin in the groin region, it is not easy to disinfect and fix thoroughly during the routine maintenance of FICCs, and so the application is prone to curl and loose, resulting in higher chances of infection and DVT. In addition, FICC cannulation with puncture site at the groin restricted the off-bed training of patients and prolonged the bed-rest, which might lead to vein return disturbances and blood hypercoagulability in the lower extremities. When patients make an involuntary movement, blood reflux and FICCs are pulled, move and fold backwards, resulting in vascular intimal injury. All the above-discussed factors increased the risk of FICC-related thrombosis. Therefore, the puncture site should be placed far away from the groin region to avoid FICC-related thrombosis. The femoral vein and femoral artery at mid-thigh accompanies each other, but their anatomical relationship varies. The positional relationship between femoral vein and femoral artery could be changed by adjusting the posture, such as by the abduction and adduction of lower extremities. Thus, it is feasible to carry out FICC cannulation with the puncture site at mid-thigh, avoiding injury to the femoral artery by mistake at the same time. This FICC puncture site maintains the FICCs out of the inguinal crease and diaper region, potentially making it more sterile and easier to maintain. In addition, it does not restrict the activities of patients and has little influence on the daily life. These characteristics effectively avoid some risk factors of FICC cannulation with puncture site at the groin and greatly reduce the incidence of thrombosis. After FICC catheterization with the puncture site at mid-thigh, patients were informed to walk normally, avoid sedentary behavior, crouching and other postures that affect the venous return of lower extremities, encouraging and urging patients to perform limb functional exercises regularly while lying in bed.

There were significantly more cases with catheter tip placed in the non-optimal position in the FICC-related thrombosis group (23.6%) than that in the non-FICC-related thrombosis group (16.7%), suggesting that the non-optimal tip position was associated with FICC-related thrombosis in our study. But this did not conclude non-optimal tip position as an independent risk factor of FICC-related thrombosis. When once the catheter was inserted, it was easy to block the blood flow, causing blood stasis and promoting the occurrence of thrombosis in the vein. When the catheter tip was placed in the optimal position, the blood flow was larger, and so it was not prone to blood stasis and hypercoagulable state, thereby reducing the incidence of thrombosis. In addition, localizing FICCs by intracavitary electrocardiography (IC-ECG) could help the catheter tip to easily reach the optimal position and improve the success rate of puncture [45].

Some studies showed that [33,46–48] the larger the diameter of the indwelling catheter was, the higher the incidence of thrombosis was. Similarly, our study also found the association of catheter size with FICC-related thrombosis, but it did not conclude small-sized catheters as independent risk factor of FICC-related thrombosis. Sharp R et al.

[49] study indicated that a 45% catheter to vein ratio as an optimal cut-off value with high sensitivity and specificity to reduce the risk of thrombosis, while patients with a catheter to vein ratio of > 45% were more likely (almost 13 times) to suffer from thrombosis. Therefore, small-sized catheters are preferable for FICC catheterization. This is because the catheter tip could enter the optimal position more easily and avoid vascular endothelial injury caused by repeated puncturing. At the same time, the tip of the small-sized catheters placed in the optimal position has less influence on the blood flow, and so it was not prone to blood stasis and hypercoagulable state, thereby reducing the incidence of thrombosis.

The results that are worth noting and discussing in our study were as follows: the increased time of puncture during FICC catheterization could lead to vascular endothelial injury, which was confirmed by the three mechanisms of thrombosis in Virchow's triad. However, our study suggested that the time of puncture showed no association with FICC-related thrombosis, which was in line with the previous study [50]. The reasons for this might be due to that the real-time ultrasound-guided FICC catheterization was punctured with a finer needle; and FICC catheterization with modified Sedinger technique guided by ultrasound could better evaluate the status and blood flow rates of blood vessels [16], detect the thrombosis in scheduled puncture vein and simultaneously monitor the catheter's movement, obviously increasing the success rate of puncture and reducing the incidence of repeated puncturing, subsequently reducing the incidence of thrombosis [5,51].

However, our study has some limitations that should be worth notifying. In our study, 874 patients with SVCS undergoing chemotherapy via FICC were selected from only one third-grade class-A hospital. They had some common aspects, which may lead to some biases and negative impact on the results of our study. As the patients in our study are particularly with SVCS, anticoagulant drugs may have been used during chemotherapy, and our study did not consider this factor. Therefore, to scientifically analyze the relationship between thrombosis and various risk factors, it is necessary to expand the sample size, conduct a prospective cohort study and control the possible confounding biases for further observation in the future.

5. Conclusion

In conclusion, FICC-related thrombosis is a serious complication after patients undergoing FICC catheterization. This, in turn, affects the follow-up treatment of patients with SVCS undergoing chemotherapy and greatly increases the cost of treatment for this disease. It is associated with history of DVT, treatment with VEGF inhibitor (bevacizumab), puncture site (mid-thigh, groin), tip position and catheter size. In addition, treatment with VEGF inhibitor (bevacizumab) and puncture site at the groin were proven to be independent risk factors for FICC-related thrombosis. Thus, it is imperative to carefully evaluate the status of blood vessels before undergoing FICC catheterization, select appropriate puncture site and catheter size according to the optimal catheter to vein ratio. The method of intracavitary electrocardiogram was recommended to localize the tip of the catheters [45] in the optimal position, subsequently reducing the incidence of FICC-related thrombosis.

Authorship/contributors

HOU Jianmei and ZHANG Jinghui provided statistical support and analysis. HOU Jianmei completed the data collection. All authors contributed to the conceptualization and design and manuscript preparation.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: this study was funded by the Natural Science Foundation of Hunan Province, China (Grant No: 2019JJ40501), and a Project of Management in Xiangya Hospital of Xiangya Hospital, Central South University (Grant No: 2016GL19). It was also supported by Hunan Science and Technology Innovation Platform and Talent Plan (The Key Laboratory of Hunan Province for Nursing (Central South University), Changsha, China—Grant No: 2017 TP 1004).

Declaration of competing interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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