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Original article

Analysis of risk factors and the establishment of a risk model for peripherally inserted central catheter thrombosis

Fang Hu [a,*], Ruo-Nan Hao [b], Jie Zhang [b], Zhi-Cheng Ma [c]

[a] Department of Nursing, General Hospital, Tianjin Medical University, Tianjin 300052, China
[b] Department of General Surgery, General Hospital, Tianjin Medical University, Tianjin 300052, China
[c] Department of General Surgery, Tianjin First Central Hospital, Tianjin 300192, China

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ABSTRACT

Objective: To investigate the main risk factors of peripherally inserted central catheter (PICC) related upper extremity deep venous thrombosis and establish the risk predictive model of PICC-related upper extremity deep venous thrombosis.

Methods: Patients with PICC who were hospitalized between January 2014 and July 2015 were studied retrospectively; they were divided into a thrombosis group ($n = 52$), with patients who had a venous thrombosis complication after PICC, and a no-thrombosis group ($n = 144$), with patients without venous thrombosis. To compare between the two groups, significantly different variables were selected to perform multivariate logistic regression to establish the risk-predictive model.

Results: The PICC catheter history, catheter tip position, and diameter of blood vessel were the key factors for thrombosis. The logistic regression predictive model was as follows: Y = 3.338 + 2.040 × PICC catheter history +1.964× catheter tip position −1.572× diameter of vessel. The area under the receiver operating characteristic curve for the model was 0.872, 95%*CI* (0.817–0.927). The cut-off point was 0.801, the sensitivity of the model was 0.832, and the specificity was 0.745.

Conclusions: The PICC catheterization history, catheter tip position, the diameter of blood vessel were the key factors for thrombosis. The logistic regression risk model based on these factors is reliable for predicting PICC-related upper extremity deep venous thrombosis.

1. Introduction

Over the past few decades, the use of peripherally inserted central catheters (PICCs) to achieve nonpermanent yet durable venous access has grown dramatically in the clinical population, especially among patients with cancer and those receiving parenteral nutrition.[1] One of the foremost complications related to a PICC is upper extremity deep vein thrombosis (UEDVT), with a 2%–26% incidence of PICC-UEDVT thrombosis. PICC-UEDVT interrupts venous therapy, increases the cost of care, and even leads to pulmonary embolism (PE) or other serious complications.[2,3] Because the clinical symptoms are poor predictors, the misdiagnosis rate for PICC-UEDVT is very high. Hence, a rapid preliminary evaluation, screening of high-risk groups, and implementation of preventive measures are effective methods to reduce PICC-UEDVT. However, while risk factors and other clinical characteristics of PICC-UEDVT have been evaluated, very little work has focused on the risk model of PICC-UEDVT. The purpose of this retrospective cohort study was to determine the risk factors related to PICC-UEDVT and establish a risk model of PICC-UEDVT to predict which patients are more likely to develop UEDVT following a PICC insertion.

2. Materials and methods

2.1. Sample

A total of 201 patients who were scheduled to receive a PICC in a Tianjin hospital between January 2014 and August 2015 were prospectively studied. All PICCs were inserted using standard sterile techniques in a sterile environment. A radiologist performed the venous access by ultrasound guidance, and a professional PICC nurse carried out the insertion procedure. Then, all PICCs were routinely checked by PICC nurses. The inclusion criteria were as follows: (1) patients who were older than 18 years of age, (2)

* Corresponding author.
E-mail address: hxc5286@sina.com (F. Hu).
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patients who had a PICC inserted by a specialist nurse and could be followed up in our hospital, and (3) patients who could tolerate an ultrasound examination. The exclusion criteria were strictly as follows: (1) patients who suffered from hemopathy, (2) patients who had another catheter on the side of PICC, and (3) patients who refused to sign an informed consent form.

2.2. Data collection

The data collection case report form contained the general information of patients, disease-related information, catheter-related information and laboratory indicators, including sex, age, obesity, number of punctures, catheter tip position, side of catheter placement, vein of PICC, diameter of blood vessel (the point of puncture), diagnosis, history of diabetes, hypertension, coronary heart disease (CHD), trauma, operation, chemotherapy, smoking, oral anticoagulants, thrombosis, PICC catheter, platelet count (PLT), and D-dimer concentration.

The data were collected and recorded by the authors and were obtained from interviews, nursing team records, or the hospital information system. All patients were investigated for venous thrombosis by Doppler sonography performed by both a specified vascular nurse and a specialist with color Doppler flow imaging certification (who knew nothing about the patients' conditions) every seven days within one month of the catheter insertion. UEDVT was diagnosed by duplex ultrasound imaging, including no compressibility of the vein, presence of visible thrombus, and lack of Doppler-detected venous flow.[4] All of the study procedures were approved by the Tianjin Ethics Committee, and written informed patient consent was obtained in the present study.

2.3. Statistical analysis

The software SPSS 17.0 was used for the data analysis. The differences of PICC thrombosis between the thrombosis group and the no-thrombosis group were evaluated with a χ^2 test or a T-test. Then, the risk factors identified by univariate analyses ($P < 0.05$) were input into a multivariate regression analysis to identify the major risk factors for thrombosis and to build a risk model for thrombosis according to their regression coefficient (beta, β). Lastly, we placed the relevant data from the cases in this study into the new model to further describe the receiver operating characteristic (ROC) curves that were used to calculate the best cut-off value and detect the model's diagnostic ability. An alpha level of 0.05 was set for statistical significance.

3. Results

3.1. General results for patients with venous thrombosis

The study included 201 patients (we lost contact with 5 patients within 1 month, so 196 patients were followed up within 1 month). Of the 196 patients assessed in our study, 90 (45.9%) were men and 106 (54.1%) were women. The age range was 18–86 years (mean 57 ± 2 years). The incidence of UEDVT was 26.5% (52 of 196 patients). The mean time interval between PICC insertion and thrombosis onset was 11.04 ± 5.54 days. The earliest thrombosis occurred on the second day after insertion, and the latest occurred 26 days after PICC placement.

3.2. Statistical results of risk factors analysis

3.2.1. Univariate analyses

A total of 21 variables were entered into invariable logistic regression analyses. Seven risk factors showed statistical significance ($P < 0.05$): the diameter of the blood vessel, catheter tip position, cancer, and history of diabetes, chemotherapy history, history of thrombosis, and PICC catheter history (Table 1).

3.2.2. Multivariate analysis

To further analyze the risk factors of PICC-UEDVT, a multivariate analysis for the seven risk factors (diameter of the blood vessel, catheter tip position, cancer, history of diabetes, chemotherapy, thrombosis, and PICC catheter) was performed. Direct access method was applied, and $P < 0.05$ was considered significant for the valid variables. The multivariate analysis revealed three statistically significant risk factors for UEDVT: the catheter tip position, diameter of blood vessel, and PICC catheter history (Table 2). According to their β, the risk model of PICC-UEDVT was built: $Y = 3.338 + 2.040X_1 + 1.964X_2 - 1.572X_3$ (X_1 = PICC catheter history, X_2 = catheter tip position, X_3 = diameter of blood vessel).

3.2.3. ROC curve and the cut-off point

We placed the relevant data from the 196 cases in this study into the new risk model to obtain the results for the two groups. Then, we described the receiver operating characteristic (ROC) curves (Fig. 1). According to the ROC curves, the area under the ROC curves (AUC) was 0.853, with 95% confidence interval of 0.760–0.945. Youden's index was at the maximum when $Y = 0.81$. Therefore, 0.81 was considered to be the cut-off point for PICC-UEDVT. The sensitivity and specificity of the model were 0.832 and 0.745, respectively.

4. Discussion

The reported incidence of PICC thrombosis varied greatly, and the risk factors of PICC thrombosis were not previously well defined. The incidence of PICC-UEDVT in the present study was 26.5%, and this figure was in accordance with that of previous research.[5] This prevalence can lead to increased medical costs, interrupted treatment, and even death. Special attention must be paid to thrombosis prevention to reduce the risk of symptomatic PICC-UEDVT.

Previous research revealed that factors such as cancer, diabetes, side of catheter line placement, catheter tip location, and catheter repositioning were risk factors for PICC-UEDVT.[2,5,6] Marnejon stated that factors such as trauma and left-sided catheters were significantly associated with PICC-UEDVT insertion.[7] Yulan-Shi revealed that age >60 years, BMI >25 kg/m^2, and WBC >11.4 × 10^9/L were major risk factors for thrombosis in Chinese patients undergoing PICC chemotherapy.[8] Other studies have shown that a history of chemotherapy, being bedridden for >72 h, a larger-diameter PICC, and malignancy increase the risk for DVT.[5,9,10] The risk factors of PICC-UEDVT have been assessed generally, but there has been less focus on the risk model for PICC-UEDVT.

In this study, we selected 21 related risk factors for invariable and multivariate analyses, concluding that the independent risk factors for PICC-UEDVT were the PICC catheter history, catheter tip position, and diameter of the blood vessel. The main reason for the difference with other studies may be the sample population (cancer patients or general patients), research design (prospective or retrospective), and diagnosis method (Doppler sonography or venography). Additionally, most of the previous studies only screened patients with symptoms (but not all patients). The impact of the factors on the model can be observed from the β in the multiple logistic regression: the greater the absolute value of the β, the greater the role played in the model. Therefore, the PICC catheter history ($\beta = 2.040$) has a maximum influence on the PICC-UEDVT, followed by the catheter tip position ($\beta = 1.964$), and then the diameter of the blood vessel ($\beta = -1.572$). One of the risk factors, having a catheter history, suggests that vessel wall irritation or