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ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA

Risk factors for development of complication following peripherally inserted central catheters: A retrospective analysis of 850 patients

Periferik yerleştirilen santral venöz kateterleri takiben komplikasyon gelişmesi risk faktörleri: 850 hastanın retrospektif analizi

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ABSTRACT

Objectives: Peripherally inserted central venous catheters (PICCs) are inserted into central veins through the upper extremity veins. In this retrospective study, we aimed to evaluate PICC procedures, related complications, their causes and factors influencing the success of the procedure during anaesthesia

Methods: 'Central Venous Catheterization Forms' filled out for 850 patients in whom a PICC was inserted by residents during general anaesthesia between November 2009 and March 2013 in the operating room of Uludag University Medical Faculty Hospital were retrospectively analysed.

Results: A total of 1174 procedures were evaluated. The most preferred vein for the first attempt was the right basilic vein (32.7%). Difficulty (more than two attempts) with the PICC procedure was correlated with the patient's age ($p<0.001$), BMI <20 kg/m² ($p<0.05$), previously used vein ($p<0.001$) and resident's experience ($p<0.001$). A total of 8.2% of patients had complications, with the most frequent complication subcutaneous haematoma at the procedure site (5.3%). Risk factors for complications were advanced age ($p<0.05$), female gender ($p=0.024$), BMI >30 kg/m² ($p<0.05$), resident with less than 4 years of training ($p=0.001$), number of PICC attempts ≥2 ($p<0.001$), more than one resident involved in the catheterization procedure ($p<0.001$) and previous failed PICC procedures ($p<0.001$).

Conclusion: We conclude that catheterization should be performed under the surveillance of a staff keeping in mind the risks of complications. In the case of failure following 2 attempts, the procedure should be handed over to a more experienced staff member. *J Clin Exp Invest 2014; 5 (1): 29-35*

Key word: Peripheral venous catheterization, complications, risk factors, incidence.

ÖZET

Amaç: Periferik yerleştirilen santral venöz kateterler (PYSK), üst ekstremite venleri kullanılarak kalbe dökülen büyük venlere ulaşılmasını sağlayan araçlardır. Bu çalışmada genel anestezi uygulamalarımız sırasında gerçekleştirdiğimiz PYSK girişimlerini retrospektif olarak inceleyerek, girişime bağlı komplikasyonları, bunların nedenlerini ayrıca girişimin başarısını etkileyen faktörleri belirlemeyi amaçladık.

Yöntemler: Uludağ Üniversitesi Sağlık Uygulamaları Araştırma Merkezi Hastanesi ameliyathanesinde Kasım 2009 - Mart 2013 tarihleri arasında genel anestezi uygulamalarımız sırasında asistanlar tarafından PYSK uygulaması yapılan ve "Santral Venöz Kateterizasyon Formu" doldurulan 850 hastaya ait formlar retrospektif olarak incelendi.

Bulgular: Hastalara toplam 1174 girişim yapıldığı ve ilk girişim için en çok sağ bazilik venin (%32,7) tercih edildiği görüldü. PYSK uygulamasının, zorluk (ikiden fazla deneme gereken) nedenleri incelendiğinde; hasta yaşı ($p<0.001$), VKİ<20 kg/m² ($p<0.05$), venin daha önce kullanılmış olması ($p<0.001$), uygulayıcının deneyimi ($p<0.001$) ile ilişkili olduğu bulundu. Hastaların %8,2'sinde komplikasyon geliştiği ve en sık görülen komplikasyonun girişim yerinde cilt altı hematom olduğu saptandı (%5,3). Komplikasyon görülmesine ait risk faktörleri; ileri yaş ($p<0.05$), kadın cinsiyet ($p=0.024$), VKİ>30 kg/m² ($p<0.05$), uygulayıcının eğitim süresinin 4 yıldan daha az olması ($p=0.001$), deneme sayısının ≥2 olması ($p<0.001$), kateterizasyon işleminde birden çok uygulayıcı olması ($p<0.001$) ve başarısız girişimler ($p<0.001$) olarak bulundu.

Sonuç: Kateterizasyon işleminin deneyimli uygulayıcıların gözetiminde yapılması, 2 denemeden sonra başarılı olunamıyorsa, girişimin daha tecrübeli olan uygulayıcılara devredilmesine dikkat edilmesi gerektiği sonucuna vardık.

Anahtar kelimeler: Periferik venöz kateterizasyon, komplikasyonlar, risk faktörler, insidans

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INTRODUCTION

Central venous catheters are very common, and they have become an important part of today's medical practice. Peripherally inserted central venous catheters (PICCs) are devices that can be inserted into the central veins near the heart through the upper extremity veins. Using peripheral veins for central venous access is a safe alternative to central venous catheterization with low cost and a low complication rate [1-5].

In this retrospective study, we aimed to determine the success rate, complications and risk factors of complications associated with PICC procedures.

METHODS

'Central Venous Catheterization Forms' filled out for 850 patients who had a central venous catheterization procedure through the peripheral veins during general anaesthesia between November 2009 and March 2013 in the operating room of Uludag University Medical Faculty Hospital were retrospectively analyzed following the approval of the ethics committee. Only one type catheter (Cavafix Certodyn 375 B. Braun, Melsungen, Germany, 16 G, 70 cm) was used. These catheters were placed by residents with guidance of intra-atrial ECG and no imaging technique was used during catheter placement. The location of the catheter tip was evaluated with chest radiography after the procedure. Residents who have had a theoretical and visual education followed by a 2-month practice period were involved in this study.

Information on the following was obtained from the forms: the patient's demographic characteristics, the type of surgery, vein or veins attempted for catheterization, vein into which the catheter was inserted, whether the catheterised vein was previously used, resident training year, number of PICC attempts, whether a p-wave amplitude change was seen on ECG upon catheter insertion and, if not, its reason, and early complications that occurred during the procedure.

Analyses were performed with IBM SPSS Statistics 20.0 software, and $p<0.05$ was defined as statistically significant. The continuous variables are expressed as mean ± standard deviation (SD) and the median (minimum-maximum) values as descriptive statistics. The categorical variables are presented as frequency and relevant percent values. Intergroup comparisons of the categorical variables were performed with Pearson's chi-square or Fischer's exact chi-square test. Correlation analysis was performed to calculate the relations between the continuous variables and Pearson's and Spearman's correlation coefficients. Multivariate logistic regression analysis was conducted to determine the independent risk factors influencing the number of attempts and complications.

RESULTS

Eight hundred-fifty patients were included in our study. The demographic data of these patients are presented in Table 1. The patient ages were between 11 and 91 years, and they weighed between 35 and 124 kg. The distribution of these patients according to the department is shown in Table 2.

Table 1. Demographic data of patients

	Mean ± SD
Age (Year)	54.82 ± 15.49
Weight (kg)	72.37 ± 13.96
Height (cm)	166 ± 8
Gender (F/M), n (%)	315 / 535 (37.1/62.9)
BMI (kg/m²)	25.97 ± 4.69

BMI: Body mass index

Table 2. Distribution of patients according to the clinics

	n (%)
Neurosurgery	204 (24)
Thoracic Surgery	184 (21.6)
General Surgery	178 (20.9)
Urology	86 (10.1)
Ear Nose Throat	73 (8.6)
Cardiovascular Surgery	51 (6)
Obstetrics and Gynecology	40 (4.7)
Orthopedics and Traumatology	30 (3.5)
Plastic Surgery	4 (0.5)

The most preferred vein for catheterization in the first attempt was the right basilic vein (32.7%), with the left medial antecubital vein less preferred (1.9%) (Table 3). In 3 patients, catheterization was performed through the right arm between the elbow and wrist or on the hand. Catheterization was performed through the first attempted vein in 684 (80.4%) patients. In 13 (1.6%) patients, 8 of whom were female, the procedure was unsuccessful. The

incidence of complications in these cases (92.3%) was higher than in successful PICC procedures (6.9%). In these unsuccessful cases, the most frequent complications were hematoma and curled catheters. No significant correlation was found between the body mass index (BMI) and the success rate of catheterization (p>0.05). In 557 (65.5%) patients, catheterization was performed by a 1st-year resident. It was performed by a more experienced 2nd- or 3rd-year resident in 280 patients (34.5%)

Table 3. Initially attempted and inserted veins in PICC procedures [n(%)]

	First attempt site, n (%)	Insertion site n (%)
Basilic vein	508 (59.8)	488 (57.4)
Right	278 (32.7)	256 (30.1)
Left	230 (27.1)	232 (27.3)
Cephalic vein	302 (35.5)	295 (34.7)
Right	146 (17.1)	143(16.8)
Left	156 (18.4)	152 (17.9)
Medial antecubital vein	40 (4.7)	51(6)
Right	24 (2.8)	28 (3.3)
Left	16 (1.9)	23 (2.7)
Veins of the hand (right)	-	3 (0.3)
Total	850 (100)	837 (98.4)*

*In 13 patients no catheter could be inserted through peripheral veins.

In the analysis of the success rates of the residents at the first attempt (Fig. 1), a significant difference was found according to the number of years training of the residents (p<0.001). The number of years of training of the resident was also significantly associated with the development of complications in the PICC procedure (p=0.001). The numbers of catheterization procedures with and without complications according to the training year of the residents are shown in Figure 2. In 42 of 70 patients who had complications (8.2%), more than one resident was involved (4.9%) and the impact of this on the development of the complications was statistically significant (p<0.001). When the experience of the residents who performed the first attempt at catheterization was assessed in relation to their training year, most of performed the first attempt at catheterization were 4th-year residents (n=388, 45.6%), and very few were staff (n=32, 3.8%). The number of attempts (535 males, 315 females) according to the genders is shown in Figure 3. There was no significant difference between genders for the number of attempts (p=0.337) and successful performances (p=0.121) Two or more catheterization attempts during the PICC procedure was regarded as denoting a difficult procedure. In terms of factors associated with a difficult procedure, there were no significant differences between genders (p=0.509). When analyzed according to BMI, patients with a BMI <20 kg/m² were more likely to have a difficult procedure (p<0.05). When we compared residents with 4 or fewer years of training with residents and staff with 4 or more years' training, the probability of a difficult procedure was lower with the latter (p<0.05). The use of a previously used vein for the first attempt was significantly associated with a difficult procedure (p<0.05). Multivariate logistic regression analysis findings regarding the risk factors associated with a difficult procedure are shown in Table 4. The patient's age was included in the model as a continuous variable. The resulting model of logistic regression was found to be significant (p<0.001).

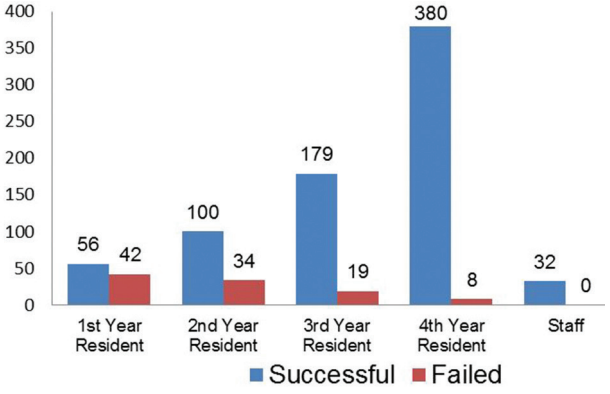

Figure 1. Successful catheterization procedures according to the training year of the first attempter (n)

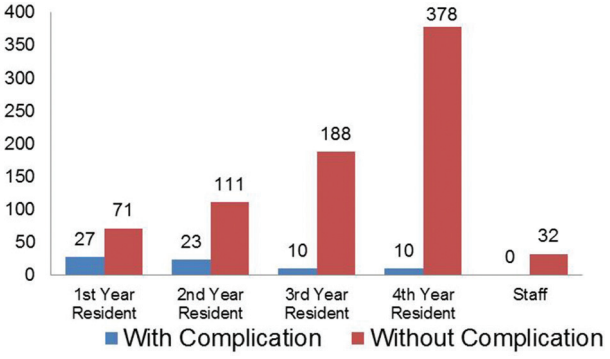

Figure 2. Number of patients with complication according to the training period of the first attempter (n)

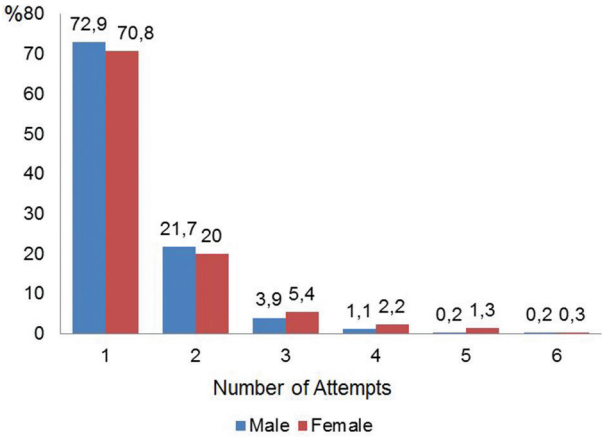

Figure 3. The range of number of attempts according to the genders (%)

In chest radiographies of 837 successful PICC procedures, malposition was detected in 1 (0.01%) of 815 patients who showed changes in p-wave amplitude with intra-atrial ECG and in 12 (54.5%) of 22 patients without amplitude change. The intra-atrial ECG technique could not be used in 8 patients due to chronic atrial fibrillation and in 2 patients due to pacemakers. The malposition rate was higher in patients whose p-wave amplitude changes were not seen with intra-atrial ECG and in those in whom this method could not be used (p<0.001; p<0.001).

No complications were seen in 780 (91.8%) patients. Some complications occurred in 70 (8.2%) patients. These complications and their distribution according to the number of attempts are shown in Table 5. The complication rate with a single attempter was 3.7%, whereas it was 40.8% with 2 or more attempters so the effect of changing attempter on the complication rate was statistically significant (p<0.05). In the analysis of the complications related to the PICC procedures, there was a statistically significant difference between male (6.7%) and female (10.8%) patients in terms of developing complications (p=0.037). In the comparison of patients with complications and without complications, a statistically significant difference was seen in terms of median values (p<0.05). In the analysis of BMI, the incidence of complications was higher in patients with a BMI >30 kg/m² (p=0.024). No significant difference was found between the catheterised veins in terms of developing complications (p=0.953). A logistic regression model was established for the risk factors for the complications that occurred during the PICC procedures (Table 6). The patient's age was included in the model as a continuous variable. The established model of logistic regression was significant (p<0.001).

Table 4. Risk factors increasing number of attempts in PICC procedures. multivariate logistic regression analysis

Variables	p value	OR	95% CI
Patients' characteristics			
Age	0.039	1.011	1.001-1.022
Gender (RC: Male)	0.385	-	-
BMI (RC: 20-30 kg/m²)	0.27	-	-
BMI < 20 kg/m²	0.01	2.051	1.19-3.535
BMI < 30 kg/m²	0.272	-	-
Vein characteristics			
Status of the catheter inserted vein (RC: not being previously used)	0.000	8.938	4.822-16.56
Attempters' characteristics			
Training year (RC: >4)	0.048	3.374	1.011-11.26

RC: Reference category. OR: Odd ratio CI: Confidence Interval. BMI: Body Mass Index.

Table 5. Complications occurred during PICC procedures and distributions according to the attempters' training years

Complications	1st year Resident	2nd year Resident	3rd year Resident	4th year Resident	Staff	Total n (%)
Artery puncture	-	1	-	-	-	1 (0.1)
Hematoma	19	15	5	6	-	45 (5.3)
Malposition	5	3	3	2	-	13 (1.5)
Curling	-	2	1	2	-	5 (0.5)
Arrhythmia	3	2	1	-	-	6 (0.7)
Total	27	23	10	10	-	70 (8.2)

Table 6. Multivariate logistic regression analysis of risk factors affecting complications occurrence in PICC procedures.

Variables	p value	OR	95% CI
Patients' characteristics			
Age	0.02	1.027	1.004-1.050
Gender (RC: Male)	0.024	2.21	1.003-2.345
BMI (RC: 20-30 kg/m²)	0.07	-	-
BMI<20 kg/m²	0.698	-	-
BMI>30 kg/m²	0.03	2.17	1.079-4.363
Vein characteristics			
Status of the catheter inserted vein (RC: not being previously used)	0.94	-	-
Attempters' characteristics			
Training years (RC: >4 years)	0.001	1.72	1.24-3.45
Number of attempts (RC: ≥2)	<0.001	10.014	4.45-22.53
Failed Attempt	<0.001	42.579	4.439-408.4
Hand change	<0.001	3.074	1.557-6.07

RC: Reference category. OR: Odd ratio CI: Confidence Interval. BMI: Body Mass Index.

DISCUSSION

Inserting catheters into central veins through the antecubital veins is a very common method used for different purposes. In our operating rooms, this method is performed by anaesthesia residents or staff. This study retrospectively evaluated 850 patients' PICC forms that were filled out in our department of anaesthesiology and reanimation.

In central venous catheterization procedures through the antecubital veins, the attempter should choose the side and the vein according to the patient's medical status, undergoing type of scheduled surgery and position given to patient for operation. According to various studies, the right side and the basilic vein are generally preferred [1,4,5]. This was also the case in our study, with the right basilic vein most commonly used (32.7%).

Different factors affect the success of PICC procedures. The rate of successful PICC procedures was reported to be between 85 and 100% [6-8]. In our study, it was 98.4%. In unsuccessful cases, catheters were inserted through the right internal jugular vein. In central venous catheterization procedures, the attempter's experience significantly affects the success of the procedure. Experience may be associated with the number of years' training year and the number of previously successfully inserted catheters. Some studies of central venous catheterization procedures showed that those with more experience have higher success rates and that mechanical complication rates are lower [9, 10]. According to the results of our study, the number of years' training of the attempter was directly related to the success rate of the first attempt of catheterization but reversely related to the complication rate.

Correctly locating the catheter tip is important to prevent some early and late complications in central venous catheterization procedures. [11-15]. For this purpose, intra-atrial ECG is very commonly used, and the success rate is relatively high, as also seen in our study, when it is used [16-18]. In two separate studies by Venkatesen et al. [5] and Minkovich et al. [19], correct positioning rates of PICC tips were higher in the right side, but the intra-atrial ECG method was not used in these procedures. Due to the routine use of the intra-atrial ECG method in our PICC procedures, we found no significant difference between side of procedures according to rates of correct positioning of the catheter tip.

Schummer et al. [20] found that while increasing number of attempts were being risk factors for unsuccessful attempts and mechanical complications, they were not for malposition. They also reported that unsuccessful procedures were seen less in male patients. Eisen et al. [9] found that success rates of catheterization were higher in male patients. However, in our study, we found no significant difference between genders regarding the suc-

cess rates. Mansfield et al. [21] reported that previously used veins decreased PICC success rate. Yılmazlar et al. [22] reported that an increase in the number of attempts increased complication rates. In our study, we found the same result (p<0.001). We found no significant difference in the number of attempts between genders.

According to the results of our study, the probability of a difficult procedure was 9 times higher with a previously used vein (p<0.001). In addition, the rate unsuccessful PICC also increased with a previously used vein (p<0.001). The probability of a difficult procedure was 3.4 times higher with fewer than 4 years' training in comparison to 4 or more years' training (p=0.048).

Central venous catheterization through the antecubital veins is an invasive procedure associated with some minor complications. Pikwer et al. [23] compared complications of central and peripheral catheters reported in 12 different studies. They reported that malposition of the tip of the catheter, thrombophlebitis and catheter dysfunction were greater with PICC procedures but that infection rates were similar in the two groups. According to the results of this study, complications related to central venous catheterization, such as pneumothorax and puncture of the carotid and subclavian arteries, explained attempter's preferences. Amerasekera et al. [24] reported the rates of malposition, haemorrhage and brachial artery puncture with PICC as 6–10%, 0.5% and 2% respectively. Another study [25] reported similar results in terms of complications.

In the data analysis of the 850 patients included in our study, several complications occurred in 70 (8.2%) patients, none of which were life threatening. Hematoma related to the procedure in the antecubital region was the most frequent complication (5.3%), and brachial artery puncture was observed in 1 patient (0.1%). According to one study, arrhythmia is rare with PICCs [24]. In 6 patients in whom arrhythmia was detected, the cardiac rhythm was improved by withdrawing the catheter, without any medication required. Continuous watching the ECG monitor during the procedure may be a preventative measure to avoid arrhythmias associated with deep placement of the catheter. Curling that was consisted due to venous branching, curves or valves, was a less common complication. There have also been some reports of persistent hiccup and brachial arterio-venous fistula associated with the PICC method [26,27].

According to our study, the incidence of complications was increased with a single attempter in comparison with 2 attempters (p<0.05). The incidence of complications was increased 3 times with more than a single attempter (p<0.001). Moreover, the complication rate was lower when the first attempter had more experience. The complication rate was 1.7 times higher with less than 4 years' training than with more than 4 years' training (p<0.001). The complication rate was 10 times more with more than one PICC attempt (p<0.001). Every needle puncture of the skin or vein causes trauma and is a risk factor for developing a complication. Our results show that the complication rates were increased in unsuccessful cases compared to successful cases (p<0.001). Schumer et al. [20] also reported that the complication rate increased with the number of attempts (p<0.001) in unsuccessful cases.

Our study demonstrate that the complication rates increased with age (p<0.05). We believe that age-related pathophysiological changes in the vessel wall and skin and the increase in accompanying chronic systemic diseases result in an increase in traumatic injury, especially during insertion of the needle through the skin. Therefore, as with all invasive procedures, we suggest that more attention is required during PICC procedures with elderly patients regarding mechanical complications. The complication rate during catheterization was 2.2 times higher in female patients than in males (p=0.024). The higher risk of mechanical complications in female patients might be associated with their more sensitive skin and vessel structure. The complication rate was 2.17 times higher in patients with a BMI >30 kg/m² (p=0.03). We think that difficulty in vein palpation, venule structure and anatomical variations of the veins in obese patients might increase the occurrence of complications during PICC procedures.

According to the results of our study, the following are associated with difficult catheterization: advanced age, a BMI <20 kg/m², a previously used vein and the number of years of experience of the attempter in PICC procedures. The risk factors for complications were advanced age, female gender, a BMI >30 kg/m², more than one person involved, a higher number of attempts, less experience and failed attempts.

In conclusion, keeping in mind these difficulties and the underlying causes of the complications, PICC procedures should be done under the supervision of staff. If the first attempter does not succeed after two attempts, a more experienced staff member should take over the procedure.

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