RESEARCH ARTICLE / ARAŞTIRMA

DOI: 10.4274/mjima.galenos.2024.23093.11
Mediterr J Infect Microb Antimicrob 2024;13:23093.11
Erişim: http://dx.doi.org/10.4274/mjima.galenos.2024.23093.11

Short Peripheral Intravenous Catheter-related Phlebitis in Patients with COVID-19: A Propensity Score-matched Study

COVID-19 Hastalarında Periferik İntravenöz Kateter İlişkili Flebit Değerlendirilmesi: Propensity Skor Eşleştirme Çalışması

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Abstract

Introduction: Peripheral intravenous catheters (PIVCs) are commonly used for intravenous therapy. A catheter is removed early when complications such as phlebitis develop. This study aimed to compare PIVC-related phlebitis, catheter dwell time, and insertion practices in patients with and without Coronavirus disease-2019 (COVID-19).
Materials and Methods: This single-center, prospective study was conducted in patients hospitalized between January 24, 2022, and June 24, 2022. All catheters were grouped as phlebitis and non-phlebitis, and risk factors were compared. Patients with and without COVID-19 were matched for phlebitis risk factors and compared for the incidence of phlebitis and catheter dwell time.
Results: A total of 932 catheters were followed up prospectively in 369 patients. Phlebitis developed in 21.8%. Poor skin elasticity, insertion shift (night shift), and antibiotic use were found as independent risk factors for phlebitis in the univariate and multivariate analyses. No difference in the incidence of phlebitis was found between patients with and without COVID-19, and no difference in phlebitis-free catheter dwell times was noted between the groups. Labor times for inserting PIVCs were significantly higher in patients with COVID-19 than in those without COVID-19 [median, 13.5 (10-15) vs. 5.0 (5-10) min, p<0.001].
Conclusion: Coronavirus disease-2019 did not increase the risk of PIVC-related phlebitis and did not directly affect phlebitis-free dwell time. Labor times for inserting PIVCs were significantly higher in patients with COVID-19 due to donning personal protective equipment. Although poor skin elasticity, insertion shift (night shift), and antibiotic use were found as independent risk factors, COVID-19 was not a significant risk factor for phlebitis. The results support the replacement of PIVCs in patients with COVID-19 when clinically indicated, whereas COVID-19 has no significant effect on catheter dwell times.
Keywords: Peripheral intravenous catheters, COVID-19, complications, phlebitis, catheter dwell time

Öz

Giriş: Periferik intravenöz kateterler, intravenöz tedavi amacıyla yaygın olarak kullanılmaktadır. Kateterlerin erken çıkarılmasının başlıca nedeni flebit gibi komplikasyonların gelişmesidir. Bu çalışma, Koronavirüs hastalığı-2019 (COVID-19) enfeksiyonu olan ve olmayan hastalar arasında periferik intravenöz kateter ilişkili flebit gelişimi, kateter kalış süreleri ve yerleştirme uygulamalarını karşılaştırmayı amaçlamaktadır.
Gereç ve Yöntem: Çalışma tek merkezli, prospektif bir çalışma olarak tasarlanmış olup, 24 Ocak 2022 ile 24 Haziran 2022 tarihleri arasında yatan hastalarda gerçekleştirildi. Tüm kateterler flebit gelişen ve gelişmeyen şeklinde gruplandırılarak risk faktörleri açısından karşılaştırıldı. Koronavirüs hastalığı-2019 enfeksiyonu olan ve olmayan hastalar flebit risk faktörleri açısından eşleştirildi ve flebit insidansı ve kateter kalış süreleri karşılaştırıldı.
Bulgular: Üç yüz altmış dokuz hastada toplam 932 kateter prospektif olarak takip edildi. Flebit gelişme oranı %21,8'di. Tek değişkenli ve çok değişkenli analizde zayıf deri elastikiyeti, kateter yerleştirme zamanı (gece vardiyası) ve antibiyotik kullanımı flebit gelişimi için bağımsız risk faktörleri olarak bulundu. Koronavirüs hastalığı-2019 enfeksiyonu olan ve olmayan gruplar arasında flebit insidansı ve flebitsiz kateter kalış süresi

Cite this article as: Özgen Top Ö, Özger HS, Bursa D, Şimşek H, Dizbay M. Short Peripheral Intravenous Catheter-related Phlebitis in Patients with COVID-19: A Propensity Score-matched Study. Mediterr J Infect Microb Antimicrob. 2024;13:23093.11.

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Received/Geliş Tarihi: 14.12.2023 **Accepted/Kabul Tarihi:** 25.07.2024
Published: 30.07.2024

açısından anlamlı bir fark saptanmadı. Periferik intravenöz kateterlerin yerleştirilmesi için gerekli süre, COVID-19 enfeksiyonu olmayan gruba kıyasla COVID-19 grubunda anlamlı derecede daha yüksekti [ortanca13,5 dakika (10-15) vs. 5,0 dakika (5-10), p<0,001].
Sonuç: Koronavirüs hastalığı-2019, periferik intravenöz kateter ilişkili flebit gelişim riskini artırmadı ve flebitsiz kateter kalış süresini doğrudan etkilemedi. Periferik intravenöz kateterlerin yerleştirilmesi için gerekli süre, kişisel koruyucu ekipman kullanımı nedeniyle COVID-19 grubunda anlamlı derecede daha yüksekti. Flebit gelişimi için zayıf deri elastikiyeti, kateter yerleştirme zamanı (gece vardiyası) ve antibiyotik kullanımı bağımsız risk faktörleri olarak bulunsa da, COVID-19 flebit gelişimi için önemli bir risk faktörü saptanmadı. Çalışma sonuçlarımız, COVID-19 hastalarında klinik endikasyon varlığında periferik intravenöz kateterlerin değiştirilmesini desteklemektedir, ancak COVID-19'un kateter kalış süresi üzerinde anlamlı bir etkisi yoktur.
Anahtar Kelimeler: Periferik intravenöz kateter, COVID-19, komplikasyon, flebit, kateter kalış süresi

Introduction

Peripheral intravenous catheters (PIVCs) are among the most frequently used vascular access devices worldwide[1]. Peripheral intravenous catheters are inserted in approximately 70% of hospitalized patients[2]. During the pandemic, most patients with severe or critical Coronavirus disease-2019 (COVID-19) are hospitalized, and they often need vascular access devices for medications, hydration, and parenteral nutrition[3]. Despite their widespread use, the failure rate is extremely high, with up to 36% failing before the end of treatment[4]. The primary reason for the early removal of PIVCs is the development of complications[4,5]. In Turkey, the complication rate that requires early PIVC removal is up to 50%. The most common complications include phlebitis and non-phlebitis complications (infiltration, extravasation, thrombosis, cellulitis, and bloodstream infections) [6]. Various risk factors, related to the patients (current infection, immunodeficiency, and diabetes mellitus; insertion in a lower extremity except for infants; female sex, and age ≥60 years), catheters (catheter type, stiffness, and size), infusion solutions [infusates with dextrose (>10%); extremes of pH or osmolarity; certain medications (depending on the dosage and length of infusion) such as potassium chloride, amiodarone, and some antibiotics; particulates in the infusate], and nursing practices (poor aseptic technique and contaminated dressings, type of dressing, infusion duration, insertion site, and first-attempt success) may affect the development of complications[7]. The rate of these complications can be reduced by appropriate catheter and catheter site selection, insertion, maintenance, and removal procedures[6].

The COVID-19 pandemic may negatively affect compliance with these medical procedures owing to an increased burden on the health system, insufficient number of healthcare workers, increased working hours, necessity of applying isolation and personal protective equipment, and increased anxiety. However, the possible effect of the COVID-19 pandemic on PIVC-associated complications has not been adequately evaluated yet, and studies are limited.[8] Thus, this study aimed to compare PIVC-related phlebitis, catheter dwell times, and insertion practices in patients with and without COVID-19.

Materials and Methods

Study Design and Setting

This single-center, prospective study was conducted in hospitalized patients with and without COVID-19 between January 24, 2022 and June 24, 2022. The study was approved by the Gazi University Clinical Studies Ethical Committee (approval no: 45, date: 24.01.2022). All participants provided informed consent. The Strengthening the Reporting of Observational Studies in Epidemiology checklist was used for this study.

Study Population

Patients aged ≥18 years, hospitalized in COVID-19 isolation wards, and had at least once Severe acute respiratory syndrome-Coronavirus-2 (SARS-CoV-2) polymerase chain reaction (PCR) positivity in nasopharyngeal or oropharyngeal samples were included in the COVID-19 group. During the study, patients hospitalized in the infectious diseases clinics with negative SARS-CoV-2 PCR and had no COVID-19-related clinical findings were considered in the non-COVID-19 group.

Data Collection

Central venous catheters were not included in the study, and only short PIVCs were evaluated. In this study, the patient's physician decided on the necessity of PIVC. After hospitalization, all PIVCs were inserted in a noninfected area with a standard procedure according to the national guidelines and Infusion Nursing Society (INS) recommendations by nurses[6,9]. In addition, the personal protective equipment required for COVID-19 (apron, mask, goggles or visor, and gloves) were used before PIVC insertion. Before the study, all nurses who will insert PIVCs were given theoretical and practical training on hand hygiene, use of protective equipment, PIVC placement and replacement, removal procedures, and PIVC complications by the hospital infection control team and experienced nurses.

All PIVCs were followed up by a nurse at 12-h intervals for the development of phlebitis, and a standard questionnaire was created based on INS and the national guidelines. Any sign of redness, local skin warmth, sensitivity, pain, swelling, or purulent drainage around the PIVC insertion site was recorded.

The severity of phlebitis was assessed using the phlebitis grading scale system of the INS guideline[6,9]. The demographic and clinical characteristics of the patients, as well as the catheter specifications, were recorded.

Antibiotics were used for treatment purposes in different indications and not for prophylaxis. However, no separate evaluation was made between antibiotic classes.

Materials

Locally manufactured Teflon catheters were used during the study, including 18- to 22-gauge catheters.

Definitions

The COVID-19 group included patients with SARS-CoV-2 PCR positivity in at least one of the nasopharyngeal or oropharyngeal samples

The non-COVID-19 group enrolled patients with negative SARS-CoV-2 PCR in nasopharyngeal or oropharyngeal samples and patients who have no COVID-19-related clinical findings.

Labor time: It is the time from donning the personal protective equipment to inserting the PIVCs.

Dwell time: The duration from the insertion to the removal of the catheter.

Statistical Analysis

Mac OS X IBM Statistical Package for the Social Sciences statistics version 25.0 (IBM Corp., Armonk, N.Y., USA) was used for data analysis. The chi-square test was used to compare categorical variables. Non-normally distributed continuous variables were compared using the Mann-Whitney U test, and normally distributed continuous variables were analyzed with Student's t-test. Categorical variables were stated as frequency and percentage (n, %), and continuous variables were presented as median (interquartile range 25-75%) or mean±standard deviation. Peripheral intravenous catheters were grouped as phlebitis and non-phlebitis and compared for phlebitis risk factors in the univariate and multivariate analyses. Multivariate analyses were performed by logistic regression. The logistic regression model included female sex, poor skin elasticity, insertion shift, PIVC labor time, unsuccessful first attempt, antibiotic use, needless connectors, parenteral nutrition, and crystalloid variables. Variables with $p<0.2$ in the univariate analysis, no high-level correlation with each other (Pearson correlation coefficient <0.6), and n>10 for categorical variables were included in the logistic regression model. After evaluating risk factors for phlebitis, the COVID-19 and non-COVID-19 groups were matched by propensity score matching. The propensity scores were estimated using logistic regression based on independent risk factors for phlebitis (skin elasticity, insertion shift, and antibiotic use). Although the p value between the first-attempt success and phlebitis was not significant in the univariate and multivariate analyses, the first-attempt success was included in the matching because an unsuccessful first attempt was associated with shorter catheter survival in our previous study[10]. One-to-one nearest-neighbor matching was used in the analysis. After matching, 226 PIVCs in the COVID-19 and non-COVID-19 groups were compared for phlebitis incidence and phlebitis development time. The log-rank test was used to compare phlebitis-free dwell times in both groups. A p value of <0.05 was considered significant.

Results

A total of 932 PIVCs were followed up prospectively in 369 patients. Moreover, 388 catheters were used in the COVID-19 group and 544 in the non-COVID-19 group. Phlebitis developed in 203 (21.8%) of the PIVC insertion cases. The frequencies of grade 1, 2, and 3 phlebitis were 60.6% (n=123), 34.5% (n=70), and 4.9% (n=10), respectively. Peripheral intravenous catheters were compared for phlebitis risk factors and presented in Tables 1 and 2.

Poor skin elasticity, insertion shift (night shift), and antibiotic use were identified as independent risk factors for phlebitis in the univariate and multivariate analyses. To evaluate the effect of COVID-19 on the development of phlebitis, PIVCs in the COVID-19 and non-COVID-19 groups were matched for the independent risk factors and first-attempt success. After matching, 226 PIVCs in both groups were compared for phlebitis incidence and phlebitis development time. No difference in the incidence of phlebitis was found between the COVID-19 and non-COVID-19 groups [19.9% (n=45) vs. 21.2% (n=48), p=0.727, chi-square test]. Moreover, no difference in phlebitis-free PIVC dwell times was found between the groups [COVID-19: 3 (2.08-3.92) vs. non-COVID-19: 4 (3.31-4.68), p=0.149, log-rank test] (Figure 1).

The labor times for inserting PIVCs were significantly higher in the COVID-19 group than in the non-COVID-19 group [median, 13.5 (10-15) vs. 5.0 (5-10) min, p<0.001, Mann-Whitney U test]. Successful first-attempt insertion before matching between the COVID-19 and non-COVID-19 groups was not significantly different [64.9% (n=252) vs. 69.9% (n=380), p=0.114].

Discussion

In this study, the main aim was to determine the difference in the incidence of phlebitis and phlebitis-free PIVC dwell times between the COVID-19 and non-COVID-19 groups; however, no difference was found between the two groups.

In this study, the incidence of phlebitis and phlebitis-free PIVC dwell times between the COVID-19 and non-COVID-19 groups was comparable. However, labor times for PIVC insertion were

Table 1. Univariate analysis of risk factors for PIVC-related phlebitis

	Phlebitis n=203	Non-phlebitis n=729	p value
Age, median (IQR 25-75%)	61 (51-70)	60 (49-70)	0.311
Female sex, n (%)	104 (51.2)	329 (45.1)	0.123
Insertion site characteristics			
Invisible/nonpalpable veins, n (%)	48 (23.6)	152 (20.9)	0.391
Poor skin elasticity, n (%)	73 (36)	199 (27.3)	0.016
Catheter size, n (%)			
20 gauge	79 (38.9)	292 (40.1)	0.769
22 gauge	124 (61.1)	437 (59.9)	
Insertion parameters			
Insertion shift, n (%) Time of day (4:00 pm to 8:00 am)	110 (54.2)	333 (45.7)	0.032
Insertion site, n (%)			
Back of hand	34 (16.7)	135 (18.5)	0.541
Wrist	25 (12.3)	87 (11.9)	
Forearm	94 (46.3)	319 (43.3)	
Antecubital	27 (13.3)	120 (16.5)	
Upper arm	11 (5.4)	43 (5.9)	
Others	12 (5.9)	25 (3.4)	
Labor time, median (IQR 25-75%)	10 (5-15)	10 (5-15)	0.022
Unsuccessful first-attempt insertion, n (%)	57 (28.1)	243 (33.3)	0.156
Dressing			
Gauze dressing	196 (96.6)	684 (93.8)	0.326
Transparent semipermeable membrane dressing	7 (3.5)	45 (6.1)	
Add-on devices used, n (%)			
3-way stopcock	101 (49.8)	329 (45.1)	0.243
Solid cannula cap	65 (32)	220 (30.2)	0.615
Needless connectors	39 (19.2)	189 (25.9)	0.049
Type of therapy, n (%)			
Bolus injections	37 (18.2)	126 (17.3)	0.755
Dextrose solution	6 (3.0)	53 (7.3)	0.026
Crystalloid solution	39 (19.2)	175 (24)	0.151
Analgesic drugs	12 (5.9)	55 (7.5)	0.426
Blood products	4 (2.0)	17 (2.3)	0.759
Antibiotics	163 (80.3)	530 (72.7)	0.028
Parenteral nutrition solutions	10 (4.9)	19 (2.6)	0.092
Total infusion time, h/d n (%)			
No infusion	4 (2.0)	20 (2.8)	0.924
<1 h	44 (21.7)	173 (23.7)	
1-6 h	81 (39.9)	270 (37.0)	
6-12 h	29 (14.3)	113 (15.5)	
≥12 h	45 (22.1)	153 (21)	
Flushing solution n (%)			
No flushing	18 (8.9)	57 (7.8)	0.371
0.9% NaCl	131 (64.5)	441 (60.5)	
0.9% NaCl and heparin	54 (26.6)	231 (31.7)	
Flushing frequency n (%)			
No flushing	18 (9)	57 (7.8)	0.347
4 h	48 (23.6)	128 (17.6)	
8 h	90 (44.3)	357 (49.0)	
12 h	24 (11.8)	98 (13.4)	
24 h	23 (11.3)	89 (12.2)	

IQR: Interquartile range, SD: Standard deviation, PIVC: Peripheral intravenous catheter

significantly longer in the COVID-19 group due to donning personal protective equipment.

Peripheral intravenous catheters are one of the most widely used invasive devices worldwide, and their overall failure rates vary between 35% and 50%. Phlebitis and non-phlebitis complications are the most important causes of PIVC failure. In prospective studies, the mean incidences of phlebitis ranged from 16.1% to 22.7%[11]. In our previous studies, incidence rates of phlebitis were 24.9% and 40.4% respectively[10,12]. In the present study, phlebitis developed in 21.8% of the total PIVCs, and complication rates were consistent with these literature data. Despite studies evaluating PIVC-related phlebitis in patients without COVID-19, to our knowledge, only a few studies are evaluating PIVC-related phlebitis in patients with COVID-19. Therefore, our results will make a positive contribution to the literature. In the present study, the frequency of PIVC-related phlebitis was not higher in the COVID-19 group than in the non-COVID-19 group. According to our results, COVID-19 is not an independent risk factor for PIVC-related phlebitis.

In the literature, many risk factors were described for PIVC-related phlebitis. Studies have emphasized that chemical, mechanical, and bacterial factors play a role in phlebitis development[11,13]. The infusion solutions (fluids with high osmolality), some medicines (e.g., amiodarone, potassium chloride, some antibiotics, and analgesics), catheter type and size, insertion site, catheter insertion in emergency and aseptic conditions, immune suppression, diabetes, and advanced age

Table 2. Multivariate analysis of risk factors for PIVC-related phlebitis

Variables	B	S.E.	Wald	p value	OR	95% CI
Female sex	-221	0.165	1.79	0.180	0.802	0.58-1.10
Poor skin elasticity	0.471	0.173	7.35	0.007	1.60	1.13-2.24
Insertion shift	0.325	0.161	4.09	0.043	1.38	1.01-1.89
PIVC labor time	0.003	0.011	0.05	0.812	1.003	0.98-1.02
Unsuccessful first attempt	0.351	0.180	3.78	0.052	1.42	0.92-2.02
Antibiotic use	0.412	0.196	4.40	0.036	1.51	1.02-2.21
Parenteral nutrition	0.687	0.406	2.86	0.091	1.98	0.98-4.40
Needless connectors	-0.321	0.213	2.28	0.131	0.72	0.47-1.10
Crystalloid	-0.280	0.205	1.87	0.170	0.75	0.50-1.12

PIVC: Peripheral intravenous catheter, CI: Confidence interval, B: Estimated regression coefficient, OR: Odds ratio, S.E.: Standard error

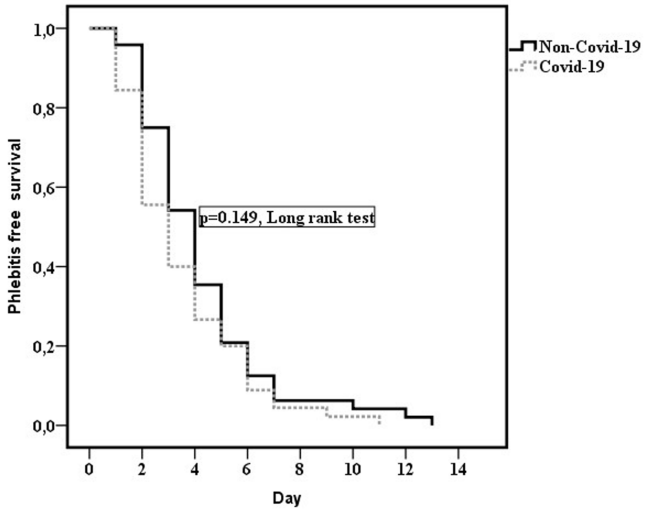

Figure 1. Phlebitis-free PIVC dwell time

PIVC: Peripheral intravenous catheter, COVID-19: Coronavirus disease-2019

are identified as risk factors for phlebitis[7]. In this study, poor skin elasticity, insertion shift (night shift), and antibiotic use were found to be independent risk factors for phlebitis.

In clinically indicated PIVC replacement, the dwell time of PIVCs without complications is one of the most important follow-up parameters[14-16]. In this study, the phlebitis-free PIVC dwell time was 3 (2.08-3.92) days in the COVID-19 group, and the phlebitis-free PIVC dwell time between the COVID-19 and non-COVID-19 group was not significantly different. These data support PIVC replacement when clinically indicated in the COVID-19 group. As far as we know, a comparison could not be made because of the lack of data on the PIVC dwell times in the COVID-19 group.

Notably, the workload for healthcare workers increased during the pandemic. In addition, the median PIVC labor time increased significantly in the COVID-19 group. This increase is probably due to the use of personal protective equipment. The use of personal protective equipment leads to challenges and additional workload when providing nursing care. Although the PIVC labor time was significantly increased in the COVID-19 group, no difference in successful first-attempt insertion was found between the two groups. Despite the use of personal protective equipment, the first successful attempt was not affected. Successful first-attempt insertion was described as an important risk factor for PIVC-related phlebitis. Therefore, the incidence of phlebitis was considered unchanged in the COVID-19 group given the similar successful first-attempt rate.

Study Limitations

This study has several limitations. First, the sample size was small and collected in two clinics of one hospital. Second, antibiotic classes were not considered in the evaluation of phlebitis. Certain types of antibiotics might be related to phlebitis. Moreover, because patients without COVID-19 are hospitalized in infectious diseases clinic, the high rate of antibiotic use should be considered.

Conclusion

Coronavirus disease-2019 did not increase the risk of PIVC-related phlebitis and did not directly affect phlebitis-free dwell time. Although poor skin elasticity, insertion shift (night shift), and antibiotic use were identified as independent risk factors, COVID-19 was not a significant risk factor for phlebitis. The results of this study support the replacement of PIVCs in patients with COVID-19 when clinically indicated, whereas COVID-19 has no significant effect on the catheter dwell time.

Ethics

Ethics Committee Approval: The study was approved by the Gazi University Clinical Studies Ethical Committee (approval no: 45, date: 24.01.2022).

Informed Consent: All participants provided informed consent.

Authorship Contributions

Concept: Ö.Ö.T., H.S.Ö., D.B., H.Ş., M.D., Design: Ö.Ö.T., H.S.Ö., D.B., H.Ş., M.D., Data Collection or Processing: Ö.Ö.T., H.S.Ö., D.B., H.Ş., Analysis or Interpretation: Ö.Ö.T., H.S.Ö., M.D., Literature Search: Ö.Ö.T., H.S.Ö., D.B., H.Ş., M.D., Writing: Ö.Ö.T., H.S.Ö., M.D.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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