RESEARCH ARTICLE

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Predictors of Complications in Patients Undergoing Port Catheter Application: A Comparative Study

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Abstract

Background: Chemotherapy is a common treatment for cancer patients that can prolong the survival of malignancies. Central venous access provides safety and comfort during chemotherapy to cancer patients. The aim of our study was predictors of complications in patients who underwent subcutaneous venous port catheter placement. **Methods:** This retrospective observational study was conducted after the approval of local review board Demographic characteristics, indications, surgical results, and complications of all patients with malignancy diagnoses undergoing subcutaneous venous port catheterization in the thoracic surgery clinics were recorded. The age, gender, indications, procedure duration, layer placement site, side, complication type and development time of the treated patients were compared. **Results:** A total of 378 patients were included in the final analysis. Forty-four (11.6%) patients had complications; 27 (7.1%) had thrombosis, 6 (1.6%) had protrusion, 4 (1.1%) had pneumothorax, 3 (0.8%) had infection, 3 (0.8%) had mispositioning, and 1 (0.3%) had cardiac arrest due to the procedure. Significant differences were observed between complication groups regarding age, sex, insertion location/side, and lymphoma presence. Logistic regression analysis identified insertion side, presence of lymphoma, and insertion location as independent predictors, with insertion side showing the strongest association (p=0.003, p=0.014 and p=0.017 respectively). **Conclusions:** It is essential to acknowledge that the application of left-sided catheters, presence of lymphoma and the selection of the internal jugular veins are associated with an increased risk of complications in patients requiring port placement.

Keywords: Cancer- Chemotherapy- retrospective observational study

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Introduction

Cancer is globally the second leading cause of death, and chemotherapy is a key modality in treating metastatic cancers, impacting long-term survival. Central venous access devices (CVAD), such as subcutaneous venous port catheters (SVPC), are a significant aspect of the safe and comfortable delivery of chemotherapy, particularly for patients who will receive long-term intravenous therapy, transfusions, or parenteral nutrition [1]. SVPC have been in wide use since their initial description by Niederhuber et al. in 1982, as their infection risks were relatively low, the risks of thrombosis were also very low, they can be used by injection, and they can be used in the outpatient setting with local anaesthesia [2, 3].

SVPC have advantages, but they may also be associated with significant complications, including catheter-related infection (5-15%), thrombosis (1-5%), pneumothorax (1-3%) and mechanical complication (malposition, occlusion) [4-7]. Although patient-associated risk factors such as obesity and immunosuppression and procedure-associated risk factors such as insertion site and operator technical skills have previously been reported as significant predictors of complications, evidence has been conflicting or largely limited to small cohort studies [8]. Some examples include recent meta-analyses of SVPCs report conflicting evidence of the impact of catheter tip position on rates of thrombosis, and limited data is available to report predictors of rare but serious complications including thromboembolism or skin necrosis [7].

This study seeks to fill these gaps by examining clinical, laboratory, and procedural predictors of SVPC complications in a large sample and by providing proposed evidence-based recommendations to ease patient selection and insertion protocols. We hope to provide valuable risk-stratification tools for clinicians to accompany existing guidelines.

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Materials and Methods

Study setting and patients

This retrospective observational study was conducted after the approval of local review board (Name of the board: University of Health Sciences Süreyyapaşa Chest Diseases and Chest Surgery Training and Research Hospital Ethics Committee, Date of approval: 02.06.2022, Approval ID: 116.2017.R-247). Demographic characteristics, indications, surgical results, and complications of all patients with malignancy diagnoses undergoing subcutaneous venous port catheterization in the thoracic surgery clinics of two training and research hospitals in Istanbul between January 2013 and July 2021 were recorded. The patients under the age of 18 years or whom with insufficient file information were excluded.

Study protocol

All catheters were placed under local anesthesia and/or sedation via Seldinger method, under sterile operating room settings. Subclavian vein (SCV) or internal jugular vein (IJV) was used. Patients were followed closely by anesthesiology team via monitorization (ECG, pulse oximetry & non-invasive blood pressure monitorization). Following appropriate disinfection (povidone-iodine) and covering with surgical drapes, local anesthesia was performed on punction site, port pocket and tunnel areas using 2% lidocaine or prilocaine. The right side was preferred primarily because of its anatomical convenience. However, in patients with prior mastectomy, radiotherapy/head-neck surgery, structural anomaly or those who were required changing of catheter due to thrombosis or infection; the contralateral side was chosen. Complications due to port implantation were recorded as early and late: those observed before first chemotherapy were recorded as early complications and those afterwards were recorded as late.

Statistical Analysis

SPSS version 29 (IBM Corp. Released 2019. IBM SPSS Statistics for Windows, Version 29.0. Armonk, NY: IBM Corp) was used to analyze the gathered data. Shapiro Wilk test was used for normality and all of the continuous data were distributed non-normally, hence the continuous data were expressed as median (25% to 75% quartiles) and Mann Whitney-U test was utilized for group comparisons. Categorical data were expressed as frequency and percentage, and Chi-Square test was used for group comparisons. Patients were categorized into two groups based on complication status: those who developed complications and those who did not. After the univariate analysis, multivariate analysis using binary logistic regression with forced-entry method was utilized. Potential predictors were selected among the variables that showed a significant difference between the groups in the univariate analysis. By logistic regression analysis, we assessed the independent association of each variable with complication risk while adjusting for potential confounding factors. Multicollinearity was checked using Variance Inflation Factor (VIF) and the goodness of fit of the regression model was evaluated with Hosmer & Lemeshow test. The performance of the model was assessed using Receiver Operating Characteristics (ROC) and area under the curve and diagnostic performance measures were reported. The level of statistical significance was set to $p<0.05$.

Outcome measures

The primary outcome of the study was to identify the predictors of complications of port insertion. Secondary outcome was to determine the key identifiers of patients who underwent port insertion and to report the common experience of the two clinics.

Results

A total of 378 patients were included in the final analysis. The median age of the patients was 60 (53 to 67) and 205 (54.2%) of the patients were male. The indication for port insertion in 373 (98.7%) of the patients was chemotherapy and palliation in 5 (1.3%). The most common types of malignancies were gastrointestinal malignancies and thoracic malignancies (N = 241, and N = 91, respectively). Forty-four (11.6%) patients had complications; 27 (7.1%) had thrombosis, 6 (1.6%) had protrusion, 4 (1.1%) had pneumothorax, 3 (0.8%) had infection, 3 (0.8%) had mispositioning, and 1 (0.3%) had cardiac arrest due to the procedure (Table 1).

There were significant differences between the complication groups in terms of age, sex, location of insertion, side of insertion, and presence of lymphoma ($p=0.047$, $p=0.042$, $p=0.008$, $p<0.001$, and $p=0.007$) (Table 2).

Age, sex, location of insertion, side of insertion and presence of lymphoma variables were included in the multivariate analysis. The assumption of goodness of fit was met (Hosmer and Lemeshow $p=0.610$). None of the variables exhibited moderate or strong correlation with each other, and all of the VIF values of the variables were <10, hence no multicollinearity was detected. The model was able to identify 14.2% of all the variance (Nagelkerke R square = 0.142) and was able to classify 88.1% of the cases correctly. Side of insertion, presence of lymphoma, and location of insertion variables were found to be independent predictors of complications ($p=0.003$, $p=0.014$, and $p=0.017$ respectively). The most valuable contribution to the model was made by side of insertion variable (Wald statistic = 9.04). The results of the logistic regression analysis were summarized in Table 3. The AUC of the model in ROC analysis to predict complication occurrence was 0.724 (95%CI = 0.640 to 0.809) (Figure 1).

Discussion

In this study, we aimed to identify predictors of complications in patients who underwent subcutaneous venous port catheter placement, finding that left-sided catheter application, presence of lymphoma and jugular vein access were independent predictors of increased risk of complication rates.

Regression analysis identified left-sided catheter application as the factor most strongly associated with an

Table 1. Descriptives of the Study Population

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Age	60 (53 to 67)
Sex (Male)	205 (54.2%)
Duration of procedure (min)	30 (25 to 40)
Location of Insertion	
Jugulary Vein	232 (61.4%)
Subclavian Vein	146 (38.6%)
Indication of Procedure	
Chemotherapy	373 (98.7%)
Palliation	5 (1.3%)
Side of Insertion	
Right	348 (92.1%)
Left	30 (7.9%)
Complications	
None	334 (88.4%)
Thrombosis	27 (7.1%)
Protrusion	6 (1.6%)
Pneumothorax	4 (1.1%)
Infection	3 (0.8%)
Malpositioning	3 (0.8%)
Cardiac Arrest	1 (0.3%)
Complications	44 (11.6%)
Early Compliations	8 (18.2%)
Late Complications	36 (81.8%)
Type of malignancy	
Gastrointestinal	241 (63.1%)
Thorax	91 (24.1%)
Sarcoma and soft tissue	16 (4.2%)
Lymphoma	12 (3.2%)
Gynecological	10 (2.6%)
Urological	4 (1.1%)
Unknown	3 (0.8%)
Skin	1 (0.3%)

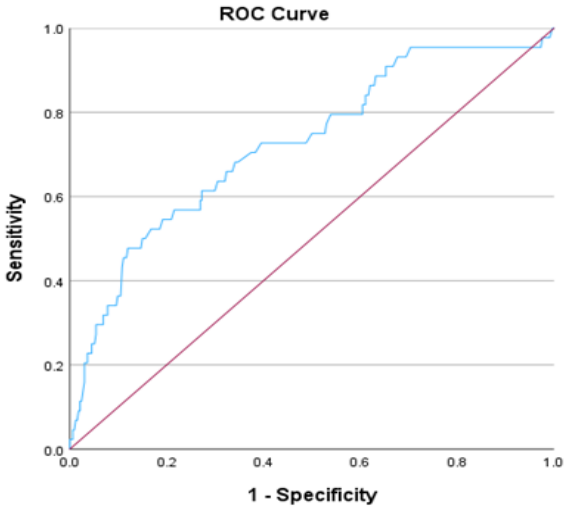

Figure 1. The Receiver Operating Characteristics Curve of the Logistic Regression Model in Predicting Complication Occurrence.

increased complication rate. There is ongoing debate in the literature regarding the optimal site for central venous catheterization [9, 10]. Right internal jugular access is generally favored due to its ease of access and suitability for ultrasound-guided procedures [9]. Additionally, malfunction rates have been reported to be higher in dialysis catheters placed on the left side compared to the right [11]. Similarly, two studies have documented significantly elevated rates of thrombosis risk associated with left-sided catheterization of both the subclavian and jugular veins [12, 13]. Our study demonstrates that left-sided catheterization significantly increase the risk of catheter-related complications. These findings are biologically plausible and supported by existing literature [14]. Left-sided insertions likely pose higher risks due to anatomical challenges the left brachiocephalic vein's sharper angle and smaller diameter increase mechanical

Table 2. Univariate Analysis of the Variables

	Non-Complicated	Complicated	p value
Age	60 (54 to 67)	57 (47 to 65)	0.047
Sex (Male)	187 (56%)	18 (40%)	0.042
Location of Insertion (Subclavian)	137 (41%)	9 (20.5%)	0.008
Side of Insertion (Left)	19 (5.7%)	11 (25%)	<0.001
Presence of Lymphoma	7 (2.1%)	5 (11.4%)	0.007
Duration of Procedure	30 (25 to 40)	30 (25 to 44)	0.677
Indication (Chemotherapy)	329 (98.5%)	44 (100%)	0.999

Table 3. The Summary of the Logistic Regression Analysis

	p value	Odds ratio (95%CI)*
Age	0.563	0.991 (0.963 to 1.021)
Sex (male)	0.142	0.587 (0.289 to 1.194)
Location of insertion (subclavian)	0.017	0.379 (0.171 to 0.840)
Side of insertion (left)	0.003	3.876 (1.603 to 9.375)
Presence of lymphoma	0.014	5.133 (1.396 to 18.870)
Constant	0.568	0.605 (NA)

* The adjusted odds ratios for independent predictors (variables with p<0.05) represent the magnitude of association between each predictor and complication risk, accounting for all other variables in the model..

stress and thrombosis susceptibility [15].

Jugular vein access was identified as another independent predictor of complications. Several studies suggest that mechanical complications are less prevalent with internal jugular vein access compared to subclavian vein access [10]. Although there is a consensus in the literature regarding an increased risk of pneumothorax associated with internal jugular vein access, other studies have indicated that thrombotic complications are less frequent in subclavian catheters [16]. Furthermore, infection rates have been reported to be lower in subclavian vein applications [9, 16].

In a 2021 study by D'Souza et al., one of the largest in the literature, it was reported that the majority of ports were placed in the right internal jugular vein due to ease of access, and the overall complication rate was 14% [17]. The authors examined the complication rates associated with the study, which analyzed a total of 12 years of data divided into two six-year periods. Notably, the complication rate in the initial six-year period was 25.6%, whereas it decreased to 11.2% during the subsequent six years. The authors attribute this decline to the accumulation of experience and the enhancement of procedural resources. Furthermore, the similarity between our complication rates and those observed in the latter half of the referenced study is noteworthy. Consistent with the findings of this study, our most frequently utilized application site is the right internal jugular vein. It is important to note that the authors did not investigate the influence of application vein and side on complication rates. Nonetheless, the resemblance between the two study settings remains striking.

For lymphoma patients, the elevated complication risk aligns with known disease-specific factors: immunosuppression from hypogammaglobulinemia and lymphoma-associated hypercoagulability [18, 19]. Notably, our results contrast with some earlier studies, possibly due to differences in insertion techniques or outcome definitions [20]. Infection is reported to be the most frequent complication associated with port catheters and that require port removal [21, 22]. Similarly, in D'Souza et al.'s study, infection was a significant cause of complications [17]. However, the authors analyzed the data across two different time periods and highlighted that infection rates decreased over time. Despite this reduction, the reported infection rates remained substantially higher than those observed in our study (8.2% vs. 0.8%). In their 2023 study, Rieger et al. attributed the high infection rate they observed in their cohort to the relatively high prevalence of hematological and soft tissue neoplasms, which required treatment with aplasia-inducing chemotherapeutic agents [23]. In our cohort, the proportion of these patients is relatively low. We believe this may elucidate the distinctly lower rates of infection as a complication in our study.

Although SVPC are accepted to be the safest method for long-term periodic venous access, some early and late complications may occur. Early complications are related to intervention towards central vein (pneumothorax, hemothorax, hematoma, cardiac arryhtmia) or reservoir implantation (wound dehiscence, seroma, wound site infection). Late complications can be categorized in two groups as those related to the catheter (obstruction of catheter, port infection, venous thromboembolism, pinch-off syndrome, catheter embolisation) or the reservoir (protrusion of reservoir from the skin, rotation of reservoir) [4]. Complication rate was reported to be 7.2 -12.5% in the literature [24, 25]. Complications were observed in 44 patients (11.6%) in our study as well, with 8 of them (18.2%) being early and 36 of them (81.8%) being late complications. We have seen pneumothorax, malposition and cardiac arrest as early complications; and protrusion of reservoir from the skin, catheter infection, skin infection, and catheter-related thrombosis as late complications.

Although univariate analysis suggested that younger age and female sex were associated with increased complication rates, multivariate analysis revealed no significant differences between the groups.

In Conclusion, consequently, it is essential to acknowledge that the application of left-sided catheters and the selection of the internal jugular vein are associated with an increased risk of complications in patients requiring port placement. Furthermore, lymphoma patients appear to face a heightened risk in this context. Randomized controlled trials are warranted to further investigate this issue.

Author Contribution Statement

All authors contributed equally in this study.

Acknowledgements

Institutional Review Board Statement

This study was conducted in accordance with the Declaration of Helsinki and approved by University of Health Sciences Süreyyapaşa Chest Diseases and Chest Surgery Training and Research Hospital Ethics Committee (02 June 2022).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest

The authors declare no conflicts of interest.

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