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ARTICLE

Comparative Predictive Modeling for PICC Line Complications in Oncology: A Retrospective Study

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Abstract

Aims/Background Peripherally inserted central catheter (PICC) are increasingly used in cancer treatment, offering significant therapeutic benefits while also posing risks for complications such as infection, thrombosis, and catheter migration. Effective prediction and management of these complications are crucial to optimizing patient outcomes and reducing healthcare costs.

Methods This retrospective study analyzed PICC line insertion in 266 cancer patients implemented from January 2019 to December 2023 at a regional healthcare facility in China. Using least absolute shrinkage and selection operator (LASSO) logistic regression, we identified key factors influencing PICC line complications and developed a tailored nomogram for individual risk assessment. The efficacy of the model was compared with support vector machine (SVM), random forest, and gradient boosting machine (GBM) using receiver operating characteristic (ROC) and decision curve analysis (DCA) metrics.

Results Factors such as body mass index (BMI), diabetic status, and age were found to be significant predictors of PICC line complications. The LASSO model demonstrated superior predictive capability (area under the curve, AUC = 0.79) over SVM (AUC = 0.40), random forest (AUC = 0.70), and GBM (AUC = 0.64). A tailored nomogram was developed for clinical use, enabling personalized risk evaluation.

Conclusion The study underscores the utility of LASSO logistic regression in the personalized risk evaluation of PICC line complications, recommending its integration into clinical practice. The tailored nomogram provides a practical tool for clinicians to enhance care customization for patients requiring PICC lines, thereby improving treatment outcomes and patient safety.

Key words: complications from PICC; cancer patient care; predictive algorithms in oncology; retrospective data analysis; risk evaluation nomogram

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Introduction

Background

Despite the increasing adoption in various cancer treatments including chemotherapy, the benefits of peripherally inserted central catheter (PICC) are usually offset by the associated complications (Madabhavi et al, 2018). Such complications can adversely affect patient care and lead to increased medical expenditures (Grau et al, 2017). Issues like infection, thrombosis, and catheter migration interrupt treatment

and compromise patient health, underscoring the need for meticulous risk factor analysis to avert such events (Spina et al, 2018). Identifying these factors is vital to formulate preventive measures and enhance the quality of care (Akhtar and Lee, 2021). Prior research has identified a spectrum of risk factors ranging from patient-specific (age, body mass index, diabetes) to catheter-centric factors (duration of use, insertion technique) (Jumani et al, 2013; Shen et al, 2022). Nevertheless, the practical applicability of these findings has often been constrained due to the limited scope of the studies (Yi et al, 2014). Addressing these limitations requires sophisticated analytical tools capable of dissecting the complex dataset intricacies to accurately predict risks (Lima et al, 2019). In this context, logistic regression, particularly the least absolute shrinkage and selection operator (LASSO) logistic regression, emerges as potent analytical tools for teasing out relevant predictive factors (Roth, 2004). The present study endeavors to apply these statistical techniques to bridge the knowledge gap in the literature and enrich our comprehension of PICC line complications in cancer patients.

Literature Review

The broad implementation of PICC in cancer patients warrants detailed examinations into their complications and risks. Contemporary research has shed light on mechanical properties, comparisons of PICC with other catheters, new insertion methodologies, and refined statistical techniques for predicting risks.

Investigations into the durability of PICC lines, such as those by Li et al (2022), have provided benchmarks for catheter endurance, finding negligible effects from prolonged usage on the mechanical integrity. Swaminathan et al (2022) delved into the relative safety of PICC lines versus midline catheters, suggesting possible advantages of the latter in terms of infection and occlusion, though the risk of Deep Vein Thrombosis (DVT) remains unclear. Li et al (2021) also contrasted PICCs with deep venous catheters in lower extremities among adults with cancer, unveiling varied outcomes based on catheter choice. Instances of PICC misplacement, as discussed by DiLoreto and Bahl (2022), call into question the reliability of certain technological aids during insertion . In a meta-analysis, Capozzi et al (2021) compared Port-a-Cath (PORT) and PICC in gynecological oncology, with the former showing a lower incidence of thrombosis and malfunction. Huang et al (2023) explored the impact of insertion techniques like the zone insertion method on patient comfort and PICC complications, advocating the potential benefits of this approach. Pinelli et al (2023) appraised the relevance of intravenous catheter guidelines, particularly MAGIC, in intensive care practices, proposing a reevaluation for current relevance. Moreover, Hinojosa et al (2021) highlighted the mechanical and infectious issues seen in pulmonary hypertension patients inserted with PICC and Hickman catheters, discovering that PICC is associated with higher complication rate. The use of advanced predictive analytics has been illustrated by Hill et al (2019) and Klén et al (2019), who employed machine learning to anticipate medical complications, showcasing the transformative impact of these methodologies in clinical settings.

Overall, the literature reflects the complex nature of PICC application in oncology, underscoring an ongoing necessity to appraise their mechanical reliability, safety, and effective insertion protocols. Besides, through literature review, it is evident that leveraging advanced analytics is becoming increasingly vital in fine-tuning risk assessment to improve patient care.

However, the existing literature extensively discusses various risk factors and complications of PICC lines but often lacks decsriptions about practical application of PICC lines and predictive capacity of analytical tool for risk prediction at the clinical level. This gap underscores the necessity for an integrated and predictive approach that employs advanced statistical tools. This study is driven by the imperative to harness these insights into a cohesive predictive model using LASSO logistic regression, aiming to improve the accuracy and clinical utility of predicting PICC line complications. By doing so, we intend to offer a robust tool that can significantly influence patient management by enhancing the prediction of complications, thereby improving treatment outcomes. This endeavor not only addresses the practical limitations highlighted in prior research but also strives to translate these academic insights into actionable, statistically validated clinical applications, thereby enhancing the care for cancer patients for whom PICC lines are required.

Methods

Study Design and Participants

This study utilized a retrospective design to examine factors predisposing cancer patients to complications from PICC line usage and how these factors influence therapeutic outcomes. We meticulously reviewed clinical records to identify the types of complications, detailed clinical characteristics of these events, and their effects on subsequent medical interventions.

The subjects were included in this study based on the following criteria: (1) patients diagnosed with any type of cancer who received a PICC line for treatment at Ningbo No.2 Hospital between January 2019 and December 2023; and (2) patients who completed at least one full cycle of chemotherapy, ensuring a minimum exposure period to assess PICC line-related complications.

The subjects with the following criteria were excluded: (1) patients with incomplete medical records and missing critical data such as demographic information, treatment details, or follow-up outcomes; (2) patients who had their PICC lines removed or discontinued treatment before completing one chemotherapy cycle, as these cases would not provide sufficient data on the impact of PICC lines as compared to those who had completed a typical, full cycle of the treatment; and (3) patients under 18 years of age, as pediatric oncology often involves different management practices and pediatric patients may exhibit varied complication profiles.

After performing a careful subject inclusion procedure, a total of 266 patients that met the inclusion criteria were included in this study. This included 38 patients who experienced complications following PICC insertion (complication group) and 228 patients who did not experience any complications (non-complication group). This structured approach to selecting participants ensures a comprehensive exami-

nation of the implications of PICC line usage across a representative sample of the cancer patients treated at our facility.

Origin and Compilation of Data

Patient data were sourced from the digital records of the regional hospital, detailing those who received PICC lines for oncological therapy within the selected timeframe. This study was approved by the Human Research Ethics Committee of Ningbo No.2 Hospital (No. PJ-NBEY-KY-2024-050-01), and written informed consent was obtained from all subjects participating in the study, and their information was stored and used for research while keeping their identity anonymous. The collected data spanned from demographic specifics, diagnostic categories, exhaustive PICC insertion details, complication occurrences with respective timings, and the treatment outcomes.

Analytical Procedures

Statistical evaluation was performed using the SciPy library in Python (3.11.5, Python Software Foundation, Beaverton, OR, USA). We began with descriptive analyses to outline the data's structure, which involved summarizing key statistics such as means, medians, and standard deviations for continuous variables, and frequencies and percentages for categorical variables. For analyzing disparities between patients exhibiting complications and those without, we utilized chi-square tests for categorical variables. These tests were conducted by creating contingency tables that compare the frequency of each category relative to the occurrence of complications. For continuous variables, the Shapiro–Wilk test was used to assess the normality of the data. Normally distributed data are expressed as mean ± SD, and the *t*-test was used to compare the means between the two groups. Initially, we identified significant variables through univariate regression analysis, followed by multivariate LASSO logistic regression to isolate independent determinants for PICC complications.

Normalization of Features and Analytical Modeling

We normalized continuous data prior to regression analysis to neutralize scale discrepancies, ensuring unbiased influence on the model. The LASSO logistic regression technique was utilized to enhance risk factor detection, employing its regularization properties to mitigate model overfitting and complexity. With a regularization intensity set at 21.54, we executed the LASSO regression using the liblinear solver, applying L1 norm penalties over a thousand iterations. A 10-fold cross-validation process, replicated thrice, substantiated the model's stability and veracity.

Assessment and Comparative Evaluation of Models

The dataset was bisected into training and testing subsets, with a fifth of the data reserved for the latter. The LASSO model formed the foundation of our comparative analysis and was evaluated for its predictability via analysis of the receiver operating characteristic (ROC) curves, which involved area under the curve (AUC) assessments. Subsequent to LASSO's benchmarking, additional models—support

vector machine (SVM), random forest, and gradient boosting machine (GBM)—were introduced and critically compared to LASSO.

Depiction of Results

Results were visualized with forest plots displaying odds ratios (ORs) and confidence intervals and a nomogram elucidating individualized risk probabilities for PICC line complications.

Statistical Interpretation

The regression outcomes, including the extrema of selected features, were thoroughly and statistically investigated, and the model's intercept alongside the optimal threshold for classification was established. This methodological framework, encompassing a retrospective approach coupled with meticulous statistical scrutiny and contemporary data analysis methodologies, undertakes a multilayered process to determine, assess, and interpret the factors associated with PICC line complications in cancer care, affirming the robustness and clinical pertinence of the insights gleaned.

Results

Descriptive Analysis

In this section, we present the baseline characteristics and initial findings from our study, which focused on cancer patients who received PICC lines for their treatments. The comparative analysis included 38 patients who experienced complications post-PICC insertion (complication group) and 228 who did not (non-complication group).

Our analysis revealed that male patients constituted 60.5% of those with complications, as opposed to 53.9% of patients without complications. However, this gender distribution did not correlate significantly with the likelihood of experiencing complications ($p = 0.451$). Similarly, the age of the patients did not show any significant differences in impacting complication outcomes ($p > 0.05$). The body mass index difference between the two groups was statistically significant ($p = 0.013$). The types of cancer, specifically lung and gastric, did not show varying complication rates between the groups. Cancer staging also showed equivalence between the two groups, with stages I–II and III not differing notably in terms of complication rates.

Interestingly, we observed that patients in the late treatment stages (stage 3) encountered complications more frequently, highlighting a potential critical point for intervention. Smoking history was notably different between the two groups, with 28.9% of patients in the complication group being smokers compared to 14.0% in the non-complication group ($p = 0.021$). Furthermore, diabetic patients were more likely to face complications, with 21.1% in the complication group versus 8.3% in the other group ($p = 0.035$).

Other factors such as a history of surgery, hypertension, coronary artery disease, the side of PICC placement, and arm circumference did not demonstrate significant differences between the two groups.

Table 1. Clinical characteristics and incidence of PICC line complications in cancer patients.

Characteristics	Complication group (n = 38)	Non-complication group (n = 228)	χ^2/t value	p-value
Male gender	23 (60.5%)	123 (53.9%)	0.570	0.451
Age group				
41–50 years	46.6 ± 3.3	46.9 ± 3.6	0.481	0.631
51–60 years	55.2 ± 4.0	54.0 ± 5.1	1.381	0.169
>60 years	69.0 ± 6.2	67.1 ± 6.8	1.614	0.108
BMI (kg/m^2)	23.4 ± 2.6	22.3 ± 2.5	2.497	0.013
Cancer type [a]			0.310	0.577
Lung cancer	6 (15.7%)	43 (18.9%)		
Stomach cancer	3 (7.9%)	14 (6.1%)		
Cancer staging			1.940	0.163
I–II	5 (13.2%)	53 (23.2%)		
III	33 (86.8%)	175 (76.8%)		
Phase of cancer treatment			16.270	0.003
0	4 (10.5%)	5 (2.2%)		
1	15 (39.5%)	159 (69.7%)		
2	19 (50%)	64 (28.1%)		
3	-	-		
Years of PICC treatment	0.066 ± 0.014	0.064 ± 0.018	0.652	0.515
Smoking status	11 (28.9%)	32 (14.0%)	5.350	0.021
Surgery history	22 (57.9%)	128 (56.2%)	0.040	0.840
Diabetes	8 (21.1%)	19 (8.3%)	4.470	0.035
Hypertension	3 (7.9%)	5 (2.2%)	1.940	0.164
Coronary heart disease	2 (5.3%)	3 (1.3%)	1.030	0.311
PICC left arm placement	10 (26.3%)	53 (23.2%)	0.170	0.680
Arm circumference (cm)	26.0 ± 2.2	26.5 ± 3.9	0.769	0.442

Note: [a] Cancer types with fewer than three cases were excluded from the statistics in the table.
Abbreviations: BMI, body mass index; PICC, peripherally inserted central catheter.

We encapsulated the demographic and clinical profiles of all participants in Table 1. This comprehensive dataset not only outlines the baseline characteristics at the time of PICC placement but also sets the stage for more detailed analyses focused on identifying risk factors linked to complications.

Table 2 delineates the specific types of complications encountered and their respective treatment responses. Identified in 52.6% of the cases, catheter malposition was the predominant factor leading to complications. This was followed by issues such as catheter rupture and occlusion, each accounting for 15.8% of complications. Other complications like rash, oozing, and thrombosis were relatively less frequent. The median duration before a complication arose was approximately 22 days. Following the insertion of PICC line, approximately 34.2% of the patients chose to retain the PICC line, whereas 36.8% required removal of the line. These data illustrate the need to execute immediate clinical decision in response to PICC line complications.

Table 2. Types of PICC line complications and the management outcomes in cancer patients.

Complication type	Complication group (n = 38)
Catheter rupture	6 (15.8%)
Catheter malposition	20 (52.6%)
Catheter occlusion	6 (15.8%)
Rash	3 (7.9%)
Bleeding	7 (18.4%)
Thrombosis	8 (21.1%)
Time interval from catheter placement to complication (days)	22 (17, 83.5) [a]
Treatment outcome	
Continued use	13 (34.2%)
Catheter removal	14 (36.8%)

Note: [a] Data expressed as median (P25, P75).
Abbreviation: PICC, peripherally inserted central catheter.

Analysis of Risk Factors

To identify predictors of PICC line complications, we first conducted univariate analyses and then used a LASSO regression model for multivariate analysis to provide a comprehensive view of the risk factors. The initial univariate analysis pinpointed five critical predictors: body mass index (BMI), smoking status, age, presence of diabetes, and the stage of cancer treatment. Notably, elevated BMI and active smoking emerged as the most substantial risk factors, followed by advanced age, presence of diabetes, and being at a later cancer treatment stage.

Subsequent multivariate analysis (Fig. 1) refined these findings by adjusting for potential confounders. This analysis revealed no significant risk difference associated with the PICC line's placement side (left or right arm; OR: 0.613, p = 0.317). Diabetes significantly increased complication risks (OR: 1.419, p = 0.022), and high BMI remained a potent risk enhancer (OR: 2.696, p = 0.001). Smaller arm circumference was linked to lower risk (OR: 0.439, p = 0.011), and age was confirmed as a notable risk factor (OR: 1.852, p = 0.015). This integrated analysis underscores the multifactorial nature of PICC line complications and highlights the nuanced contributions of BMI, diabetes, and age in predicting risk, providing a more holistic understanding of the factors involved.

Development of a Clinical Nomogram

A clinical nomogram (Fig. 2) was developed to facilitate the practical application of the study's findings. This user-friendly tool integrates identified risk factors such as age, BMI, smoking status, diabetes status, and the phase of cancer treatment, assigning a quantifiable score to each. These scores are then aggregated to yield a cumulative risk score that correlates with the probability of developing complications. In the nomogram, each increment in age and BMI corresponds to an increase in the risk score, highlighting the significance of these factors in predicting complications. Being a smoker substantially adds to the risk, emphasizing its impact as a notable risk factor. Similarly, a positive diabetes status increases the

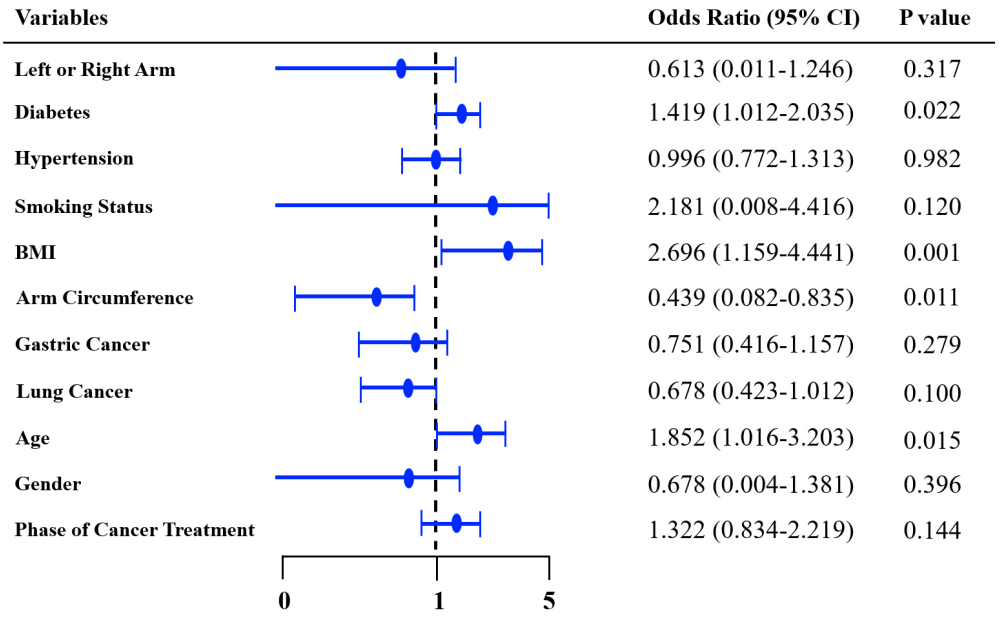

Fig. 1. Forest plot of multivariate analysis showing odds ratios and 95% confidence intervals for risk factors associated with PICC line complications. Abbreviations: BMI, body mass index; PICC, peripherally inserted central catheter.

risk score, underlining the influence of this condition on complication likelihood. Additionally, progression through the stages of cancer treatment also increases the risk, with later stages carrying higher scores. A scale was plotted for each of these factors to directly translate the total score into a probability of developing complications, providing a straightforward method for assessing risk. Notably, while arm circumference was significant in multivariate analysis, it was omitted from the nomogram due to their lesser practical relevance in routine clinical assessments, so that only the most impactful and manageable factors were analyzed. This strategic exclusion was made to balance the tool's clinical utility with ease of use.

Performance Assessment of the LASSO Logistic Regression Model

The performance of the LASSO logistic regression model was rigorously evaluated using two analytical methods, as depicted in Fig. 3. The ROC curve, as shown in Fig. 3A, assesses the model's ability to distinguish between patients who will and will not develop PICC line complications. With an AUC of 0.7901, the model demonstrates excellent discrimination capabilities, effectively differentiating between the two patient outcomes across various decision thresholds.

The effectiveness of our predictive model was further supported by the decision curve analysis (DCA) presented in Fig. 3B, which illustrates the net benefits of using the model over a range of probabilities. The DCA confirmed that the model provides substantial benefits compared to treating all patients as if they would either all have complications or none would, particularly useful for optimizing care in clinical settings without causing overtreating. Specifically, the DCA showed a maximum net benefit of 0.1667.

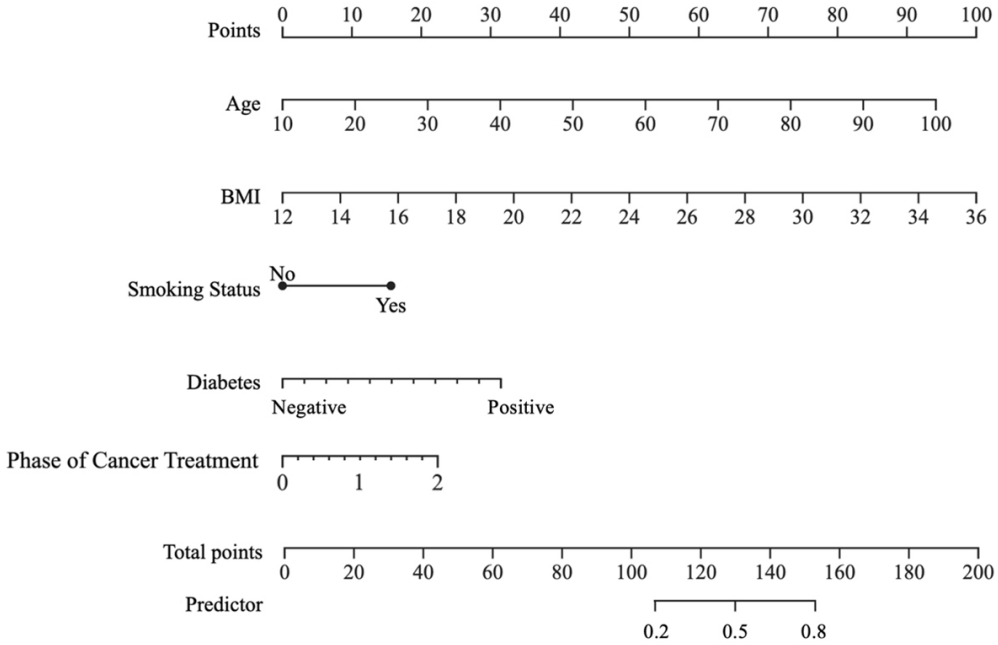

Fig. 2. Nomogram for predicting the individual risk of peripherally inserted central catheter (PICC) line complications in cancer patients.

Additionally, the model's performance was assessed using a confusion matrix, which highlighted an accuracy rate of 83.33%. The model proficiently identified patients without complications (45 true negatives), but was less effective in detecting true positives among those with complications.

These findings highlight the model's utility in clinical decision-making, offering a reliable tool for predicting PICC line complications and supporting healthcare professionals in their interventions.

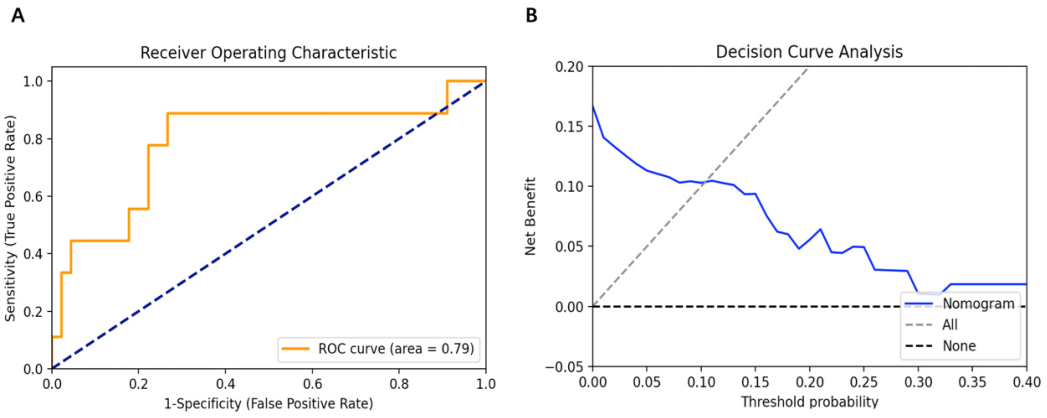

Fig. 3. Performance and clinical utility of the LASSO model for PICC complications. (A) Receiver operating characteristic (ROC) curve for the LASSO logistic regression model predicting PICC line complications. (B) Decision curve analysis (DCA) of the LASSO logistic regression model for clinical net benefit. Abbreviations: LASSO, least absolute shrinkage and selection operator; PICC, peripherally inserted central catheter.

Comparative Performance Analysis of Machine Learning Models

In our further evaluation, we compared the LASSO logistic regression model with three other machine learning models: SVM, random forest, and GBM. The comparative performance is visually represented in Fig. 4, where Fig. 4A displays the ROC curves for each model, and Fig. 4B details their respective AUC values.

The LASSO model's AUC of 0.79 suggests a superior ability to correctly identify at-risk patients, contrasting sharply with the SVM's AUC of 0.40, which indicates a relatively poor performance. Both the random forest and GBM models showed moderate effectiveness with AUCs of 0.70 and 0.64, respectively. The LASSO model's higher AUC not only reaffirms its robustness but also underscores its advantageous position in clinical applications, yielding fewer false positives and negatives than its counterparts.

This comparative analysis solidifies the LASSO logistic regression model as the more effective predictive tool compared with other evaluated options, due to its accuracy and enhanced potential to facilitate improved patient management outcomes. The model's predictive precision ensures that it is an essential asset in the toolkit of healthcare providers, aiding more informed and effective clinical decisions.

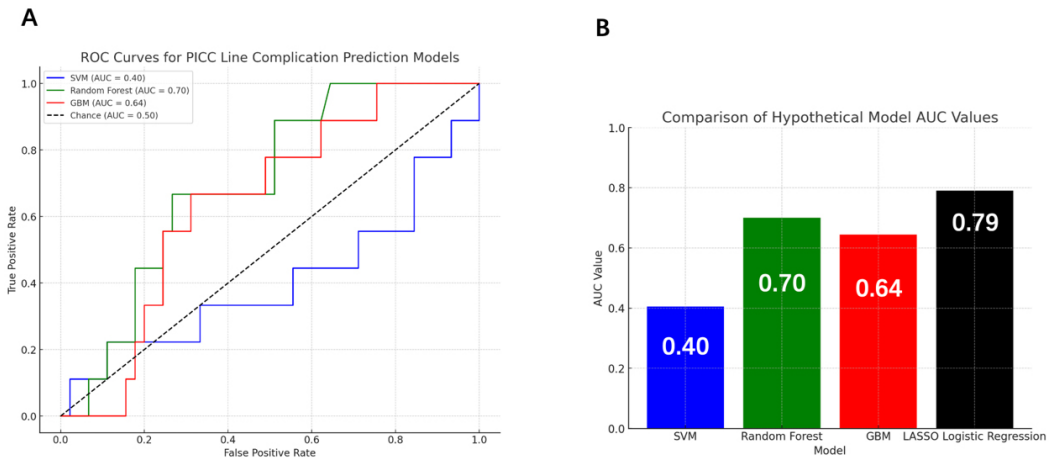

Fig. 4. Performance comparison of LASSO logistic regression and machine learning models for predicting PICC line complications. (A) Receiver operating characteristic (ROC) curve analysis of SVM, random forest and GBM. (B) Area under the curve (AUC) value comparison of all predictive models. Abbreviations: GBM, gradient boosting machine; LASSO, least absolute shrinkage and selection operator; PICC, peripherally inserted central catheter; SVM, support vector machine.

Discussion

This investigation offers a detailed examination of risk factors for PICC line complications among cancer patients, enhancing our understanding of PICC line complications and offering vital clinical insights crucial for deterring the risks. Notably, our findings challenge the traditional preference for placing PICC lines in the non-dominant arm to reduce mechanical complications, as our results indicate no

significant difference in complication rates between the left and right arms. This is supported by other study findings that arm choice may not universally affect complication risks (Scrivens et al, 2020), suggesting that decisions regarding the placement side lie in individual patient factors.

Diabetes was identified as a significant predictor of complications, supporting literature that implicates poor glycemic control in increased infection and complication risks due to compromised immune function (Beckman and Creager, 2016; Jafar et al, 2016). This connection underscores the need for stringent glycemic management in diabetic patients with PICC lines to mitigate complication risks.

Although hypertension did not show a significant correlation with increased complication risk, smoking appeared to slightly elevate the risk, aligning with its known detrimental effects on vascular health and potential to exacerbate thrombosis in PICC lines (Messner and Bernhard, 2014). The substantial risk linked with higher BMI highlights obesity as a critical factor for vascular access issues, advocating for meticulous PICC line management in obese patients to prevent complications.

The analysis also illuminated age as a noteworthy risk factor, reflecting the broader medical principle that older patients generally have a higher complication risk due to physiological aging and increased comorbidities (Kaplan et al, 1999). This finding emphasizes the necessity for careful monitoring and management of older patients with PICC lines.

The absence of significant differences based on gender and specific cancer treatment stages likely reflects the complex, multifaceted nature of PICC line complications, where no single factor acts independently. This complexity suggests that further large-scale studies are needed to uncover subtler associations that our study might not have detected.

The development of a clinical nomogram from our research findings provides a practical tool for healthcare providers. This nomogram simplifies the complex statistical data into a format that is easily interpretable, facilitating personalized risk assessments and enhancing the clinical management of patients with PICC lines (Chen et al, 2024).

The model's robustness is evidenced by an ROC curve with an AUC of 0.7901, demonstrating its capability to effectively discriminate between patients at different risk levels for complications. Additionally, the DCA accentuated the model's utility, showcasing significant net benefits over a range of clinical decision thresholds (Van Calster et al, 2018).

Moreover, the observed disparity in age being a predictor of PICC line complications between univariate and multivariate analyses underscore the need to conduct multifactorial risk assessments. Such analyses reveal the complex interactions among risk factors and confirm the significance of age as a predictor only when viewed in conjunction with other variables, highlighting the necessity of comprehensive approaches in studying PICC line complication dynamics.

Additionally, the decision to omit certain variables such as arm circumference and phase of cancer treatment from the nomogram, despite their significance in multivariate analysis, was driven by the aim to enhance the tool's practical use in

clinical environments. Integrating variables that provide the most significant and actionable insights, the nomogram is designed to be not only statistically robust but also practically relevant, aiding clinicians in making informed decisions quickly and effectively. This approach highlights our commitment to creating a tool that balances detailed statistical analysis with real-world applicability, ensuring it remains invaluable in clinical risk assessment and patient management.

The differentiation in the impact of risk factors, such as the inclusion of age in the multivariate analysis, but not in the univariate one, along with the nuanced role of BMI, underscores the complexity inherent in predicting PICC line complications. These variations necessitate a comprehensive and meticulous evaluation of risk factors, blending statistical models with clinical insights to foster a more sophisticated approach to healthcare. By integrating multifaceted analytical techniques, our study enhances the understanding of how different variables interact and influence the likelihood of complications, which is crucial to developing more precise and individualized patient care.

Our comparative analysis highlights the LASSO logistic regression model as notably superior in predicting PICC line complications when measured against SVM, random forest, and GBM models. With an AUC of 0.79, the LASSO model significantly outperforms the others, affirming not only its efficacy in clinical prediction but also its utility in reducing the occurrence of both false positives and negatives—features that are critical for clinical decision-making where the stakes are high. The underperformance of the SVM model, with an AUC of 0.40, suggests its limited reliability in this context, whereas the moderate accuracy of the random forest and GBM models indicates potential areas for further refinement and data integration.

While our study provides valuable insights, it is not devoid of limitations. The retrospective nature of the study introduces potential selection and information biases, which we have endeavored to address through meticulous data handling and validation techniques. However, prospective studies are necessary to further substantiate our findings. Additionally, the single-center scope of data collection in this study may limit the broader applicability of the results, highlighting the need for multi-center studies to confirm these findings across diverse populations.

Conclusion

Our investigation identifies BMI, diabetes, and age as primary predictors of PICC line complications in cancer patients. These findings reinforce the necessity of considering these factors not only in the clinical risk assessments but also in the proactive management of patients. Leveraging these insights, a predictive nomogram was developed to provide a practical and effective tool for healthcare providers, enabling personalized patient management and enhancing treatment outcomes. By incorporating these predictive models into routine clinical protocols, we can significantly improve patient safety and optimize treatment efficacy in oncological care. Future research should explore integrating a more data-driven approach

in healthcare in order to refine PICC line management and elevate the standard of care for cancer patients.

Key Points

- LASSO logistic regression has superior predictive accuracy over support vector machine, random forest, and gradient boosting machine models in predicting PICC line complications.
- Body mass index, diabetic status, and age are significant predictors of PICC line complications, making them crucial factors for consideration in clinical risk management.
- A practical nomogram was developed in this study to facilitate clinical evaluation of individual patient risks, with the aim to strengthen personalized care for cancer patients.
- The LASSO model holds huge potential in the optimization of PICC line management and the prediction of patient outcomes, thereby warranting incorporation into clinical practices.

Availability of Data and Materials

The datasets used during the current study are available from the corresponding author on reasonable request.

Author Contributions

FFZ, GJY: data collection, methodology and analysis, investigation. FFZ: writing—original draft. PC: data visualization, formal analysis. ZYG: supervision, conceptualization, writing—reviewing. All authors contributed to important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The present study followed the Declaration of Helsinki. This study was approved by the Human Research Ethics Committee of Ningbo No.2 Hospital (No. PJ-NBEY-KY-2024-050-01), and written informed consent was obtained from all subjects participating in the trial, and their information was stored and used for research anonymously.

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Conflict of Interest

The authors declare no conflict of interest.

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