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ARTICLE

Identifying Prostatic Utricle Translucent Membrane in Hematospermia Patients Using a Novel Nomogram

Lang Wang[1,2], Zhen Wang[1], Mingmin Shao[3], Zhenzhen Jia[1,2], Zhiwen Huang[1,2], Mingming Lu[1,2], Junfeng Jing[1,*], Yanbin Zhang[1,2,*]

[1]Department of Urology, The Second People's Hospital of Hefei, Hefei Hospital Affiliated to Anhui Medical University, Hefei, Anhui, China
[2]The Fifth Clinical School of Medicine, Anhui Medical University, Hefei, Anhui, China
[3]College of Humanities and Social Sciences, Shanxi Medical University, Taiyuan, Shanxi, China
*Correspondence: easternjjf@163.com (Junfeng Jing); doczyb@sina.com (Yanbin Zhang)

Abstract

Aims/Background Hematospermia, characterized by blood in the ejaculate, is a common and distressing condition in urology. Identifying the underlying causes, including translucent membranes in the prostatic utricle, is crucial for effective management. Despite advancements in diagnostic techniques, reliable predictive tools are needed to enhance preoperative planning and patient outcomes. This study aimed to develop a novel nomogram to predict the presence of translucent membranes in the prostatic utricle of hematospermia patients.

Methods In total, 284 patients were selected from The Second People's Hospital of Hefei database based on inclusion and exclusion criteria. The cohort was divided into a training set (198 patients) and a validation set (86 patients). To identify risk factors associated with the prostatic utricle translucent membrane, multivariable logistic regression analysis was employed. The identified risk factors were then used to construct a predictive nomogram model. The performance of the nomogram was evaluated using several statistical tools: receiver operating characteristic (ROC) curves to assess discriminative ability, calibration curves to evaluate prediction accuracy, and decision curve analysis (DCA) to determine clinical utility.

Results The findings revealed that age, duration of disease, history of seminal vesiculitis, and seminal vesicle dimensions (width, length, and thickness) were independent risk factors for the presence of a prostatic utricle translucent membrane in patients with hematospermia. Using these variables, a nomogram was developed. The nomogram demonstrated strong predictive capability, as evidenced by its performance in ROC and calibration curve analyses. Furthermore, the DCA indicated that the nomogram offered significant clinical net benefits in predicting the presence of a translucent membrane.

Conclusion Clinical use of the developed nomogram can assist clinicians in identifying patients with hematospermia who have translucent membrane in the prostatic utricle and in developing individualized treatment.

Key words: hematospermia; membrane; nomogram; prostatic utricle

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Introduction

Hematospermia, characterized by blood in the ejaculate, is a common occurrence in urology and can significantly impact patients' quality of life (Drury et al, 2022; Khodamoradi et al, 2020). Its etiology varies and includes infection, inflammation, vascular abnormalities, and tumors; however, it often remains idiopathic despite extensive investigation. Treatment ranges from conservative management to surgical interventions. Transurethral seminal vesiculoscopy (TSV) has emerged as the preferred method for diagnosing and treating disorders of the seminal vesicles and ejaculatory duct region. TSV is regarded as the gold standard because it provides direct visualization and access to these structures, enabling diagnostic and therapeutic procedures (Pang et al, 2020).

A critical aspect of TSV is the successful entry into the seminal vesicles. The most common site for endoscopic access is via the prostatic utricle. During this procedure, some patients may present with localized translucent membranes on the lateral wall of the prostatic utricle. At this juncture, a guide wire or an endoscope can be used to puncture the membrane, facilitating access to the seminal vesicles and significantly reducing the complexity and duration of the surgery (Liu et al, 2014; Yao et al, 2023).

Identifying translucent membranes in patients with hematospermia is clinically significant for several reasons (Karatas et al, 2015; Möller et al, 2005; Wang et al, 2020). Firstly, the presence of these membranes can complicate the surgery, making it crucial for surgeons to anticipate and prepare for their presence. Secondly, understanding the risk factors associated with these membranes can help in preoperative planning and patient counseling, leading to more informed decision-making and tailored surgical approaches. Lastly, identifying these membranes early can improve surgical outcomes by reducing operative time and minimizing complications.

Despite these advancements, further research is necessary to better understand the risk factors for translucent membranes in patients with hematospermia. Therefore, there is a pressing need to develop a reliable tool for accurately predicting the presence of translucent membranes in the prostatic utricle among patients with hematospermia. Such a tool would enhance preoperative planning and surgical precision while contributing to personalized patient care.

This study aimed to analyze clinical and radiological data from the database of The Second People's Hospital of Hefei, focusing on patients with hematospermia, to construct a predictive nomogram for identifying translucent membrane in the prostatic utricle within this cohort.

Methods

Study Population

Data were retrieved from the case database for patients diagnosed with hematospermia. The inclusion criteria were patients clinically diagnosed as hematospermia with preoperative magnetic resonance imaging (MRI) of the seminal vesicle region and undergoing seminal vesiculoscopy. The exclusion criteria were patients who did not receive MRI examination and not undergo seminal vesiculoscopy. In total, 284 patients met these criteria and were included in the study. They were randomly divided into training and validation sets in a 7:3 ratio. This retrospective study was approved by the Ethics Committees of The Second People's Hospital of Hefei and adhered to the ethical principles outlined in the Declaration of Helsinki [approval number: 2024-KY-011]. Written informed consent was obtained from the patients.

Data Collection and Definition of Translucent Membrane

The collected patient demographics included age, smoking history, body mass index (BMI), disease duration, and MRI parameters, including seminal vesicle width, length, and thickness. For modeling purposes, the dimensions of the seminal vesicle were scaled up by a factor of 100. In this study, the presence of a membrane was defined as the intraoperative microscopic detection of a translucent membrane on the lateral wall of the prostatic utricle during seminal vesiculoscopy.

Statistical Analyses

All statistical analyses were performed using R software (version 4.3.0, R Foundation for Statistical Computing, Vienna, Austria). p-values of less than 0.05 were considered statistically significant. To compare continuous variables between the training and validation sets, either the Mann-Whitney U test or the t-test was applied. In contrast, the chi-square test was used to compare categorical variables. Continuous variables were described using the mean and standard deviation (SD) for normally distributed data, and the median [min, max] for non-normally distributed data. Categorical variables were presented as frequency and percentage. The normality of continuous variables was assessed using the Shapiro-Wilk test. Variables that followed a normal distribution were further analyzed using parametric tests, while non-normally distributed variables were analyzed using non-parametric tests.

Logistic Regression Analysis

Univariate Logistic Regression Analysis

Initially, univariate logistic regression analyses were conducted to identify potential risk factors associated with translucent membranes. Each variable was individually analyzed to determine its odds ratio (OR) and 95% confidence interval (CI). Variables with p-values less than 0.05 were considered significant and selected for inclusion in the multivariable logistic regression analysis.

Multivariable Logistic Regression Analysis

Variables significant in the univariate analysis were included in the multivariable logistic regression model. The multivariable analysis aimed to identify independent risk factors while controlling for the effects of other variables. The stepwise selection method was used to build the model, with both forward selection and backward elimination steps based on the Akaike information criterion (AIC) to determine the final set of significant variables.

The multivariable logistic regression model provided an adjusted odds ratio and 95% confidence interval for each independent risk factor. This analysis helped identify the most significant predictors of translucent membranes in patients with hematospermia.

Based on the multivariable logistic regression analysis results, a nomogram was developed to predict the occurrence of a translucent membrane in the prostatic utricle. Each variable in the final model was assigned a score, and the total score for each patient was calculated to estimate their probability of having a translucent membrane. ROC curves were generated to assess the discriminative ability of the nomogram. The area under the ROC curve was calculated for both training and validation sets to evaluate the model's accuracy. Calibration curves were created to assess the agreement between the predicted probabilities and the observed outcomes. A model with good calibration will have predictions that lie close to the diagonal line of the calibration plot. Furthermore, a decision curve analysis (DCA) was used to evaluate the clinical utility of the nomogram by quantifying the net benefits across different probability thresholds. This analysis helped determine the nomogram's potential impact on clinical decision-making. The predictive accuracy of the nomogram was evaluated separately in the training and validation sets.

Results

Basic Information of the Patients

In total, 284 patients with hematospermia met the inclusion criteria from the case database. Of these, 198 patients were randomly assigned to the training set, while 86 were allocated to the validation set. Translucent membranes were observed in 127 patients, corresponding to a prevalence of 44.7%. As illustrated in Table 1, no statistically significant differences existed between the training and validation sets.

Univariate and Multivariable Logistic Regression

Multivariable logistic regression analysis of the training group identified age, disease duration, seminal vesicle width, thickness, length, and a history of seminal vesiculitis as independent risk factors for the presence of translucent membranes in patients with hematospermia, as shown in Table 2.

Development and Validation of Nomogram

Based on the multivariable logistic regression analysis results, we developed a nomogram to predict the occurrence of translucent membranes in the prostatic utricle of patients with hematospermia. The nomogram demonstrates that seminal vesicle width is the most critical factor influencing the appearance of translucent membranes, followed by the duration of the disease. Each factor in the nomogram was assigned a specific score, and the total score for each patient corresponded to their probability of membrane occurrence, as depicted in Fig. 1.

According to Fig. 2, the area under the ROC curve for the nomogram was 0.808 (95% CI: 0.751–0.872) in the training set and 0.766 (95% CI: 0.673–0.862) in the validation set, indicating excellent discriminative ability and predictive accuracy.

Calibration curves for both training and validation sets show a high level of agreement between predicted and observed results, as indicated by their alignment with the diagonal line shown in Fig. 3.

Fig. 4 presents the decision curve analysis (DCA) for evaluating the clinical net benefits of the nomogram. The DCA illustrates the net benefit of using the nomogram to predict the presence of translucent membranes at various threshold proba-

Table 1. Clinical and magnetic resonance imaging characteristics of patients with hematospermia (n (%)).

	Training cohort (n= 198)	Validation cohort (n = 86)	*p*-value	$t/Z/\chi^2$
Age (years)				
Mean ± SD	40.40 ± 10.70	41.30 ± 10.60	0.514	$t = -0.653$
Smoking			0.684	$\chi^2 = 0.165$
No	41 (20.7%)	16 (18.6%)		
Yes	157 (79.3%)	70 (81.4%)		
BMI (kg/m²)				
Mean ± SD	20.20 ± 5.05	21.30 ± 4.52	0.080	$t = 1.764$
Course of disease (months)				
Median (Min, Max)	11.00 [7.50, 28.00]	9.00 [7.00, 27.00]	0.571	Z = –0.564
Width (mm)				
Mean ± SD	175.00 ± 8.80	173.00 ± 11.20	0.107	$t = 1.615$
Length (mm)				
Mean ± SD	403.00 ± 11.80	404.00 ± 11.00	0.504	$t = -0.670$
Thickness (mm)				
Mean ± SD	143.00 ± 8.54	143.00 ± 7.10	0.970	$t = 0.038$
Seminal vesiculitis			0.075	$\chi^2 = 3.181$
No	82 (41.4%)	26 (30.2%)		
Yes	116 (58.6%)	60 (69.8%)		
Membrane			0.369	$\chi^2 = 0.807$
No	106 (53.5%)	51 (59.3%)		
Yes	92 (46.5%)	35 (40.7%)		

BMI, body mass index; SD, standard deviation.

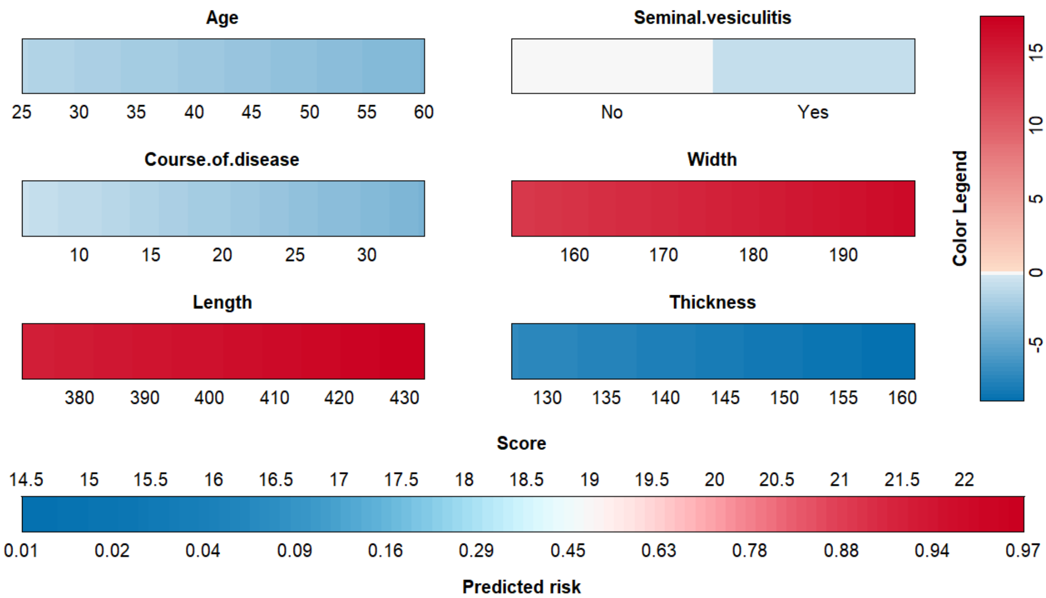

Fig. 1. Models to predict the risk for translucent membranes in patients with hematospermia.

Table 2. Univariate and multivariablelogistic regression for analyzing the risk factors for translucent membrane in the training cohort.

Variable	Univariate analysis					Multivariable analysis				
	OR (95% CI)	β	S.E	Z	*p*	OR (95% CI)	β	S.E	Z	*p*
Age	0.96 (0.94–0.99)	–0.04	0.01	–2.65	0.008	0.94 (0.91–0.97)	–0.06	0.02	–3.48	<0.001
Smoking	1.01 (0.51–2.00)	0.01	0.35	0.02	0.986	-	-	-	-	-
BMI	1.01 (0.96–1.07)	0.01	0.03	0.44	0.663	-	-	-	-	-
Course of disease	0.91 (0.86–0.96)	–0.10	0.03	–3.61	<0.001	0.89 (0.84–0.95)	–0.12	0.03	–3.72	<0.001
Width	1.06 (1.03–1.10)	0.06	0.02	3.43	<0.001	1.09 (1.04–1.14)	0.09	0.02	3.98	<0.001
Thickness	0.95 (0.92–0.98)	–0.05	0.02	–2.84	0.004	0.95 (0.91–0.99)	–0.05	0.02	–2.66	0.008
Length	1.03 (1.01–1.06)	0.03	0.01	2.65	0.008	1.04 (1.01–1.07)	0.04	0.02	2.74	0.008
Seminal vesiculitis	0.36 (0.20–0.65)	–1.01	0.30	–3.40	<0.001	0.41 (0.21–0.81)	–0.89	0.35	–2.55	0.011

OR, odds ratio; CI, confidence interval.

bilities. The x-axis represents the threshold probability, which is the probability at which a clinician would opt to perform an intervention based on the nomogram's prediction. The y-axis represents the net benefit, calculated as the number of true positives minus the number of false positives, and weighted by the relative harm of a false positive result. The decision curve shows that the nomogram provides a net benefit across a range of threshold probabilities. For instance, at a threshold probability of 0.5, the nomogram provides a significant net benefit compared to either treating all patients or treating none. Specifically, the net benefit at this threshold is approximately 0.15, indicating the nomogram can improve patient outcomes by effectively identifying those who are most likely to benefit from further intervention.

Discussion

This study developed and validated a nomogram to predict the presence of translucent membranes in the prostatic utricle of patients with hematospermia. The nomogram demonstrates excellent predictive accuracy and clinical utility, as evidenced by its performance in ROC analysis, calibration, and decision curve analyses.

Compared to previous study, our findings align with the results of Chen et al (2021), who highlighted seminal vesicle dimensions' significance in predicting hematospermia-related complications. Our study extends his work by incorporating additional risk factors such as age, duration of disease, and history of seminal vesiculitis, thereby enhancing the model's predictive power. Similarly, Furuya et al (2016) identified age and seminal vesiculitis as significant predictors, corroborating our results. Although these parameters are all associated with seminal vesicle abnormalities, further research has suggested incorporating more imaging data to enhance the model's accuracy (Wang et al, 2020). For example, Wang et al (2020) proposed additional imaging indicators related to hematospermia through real-time transrectal ultrasound-guided seminal vesiculoscopy, which could supplement our

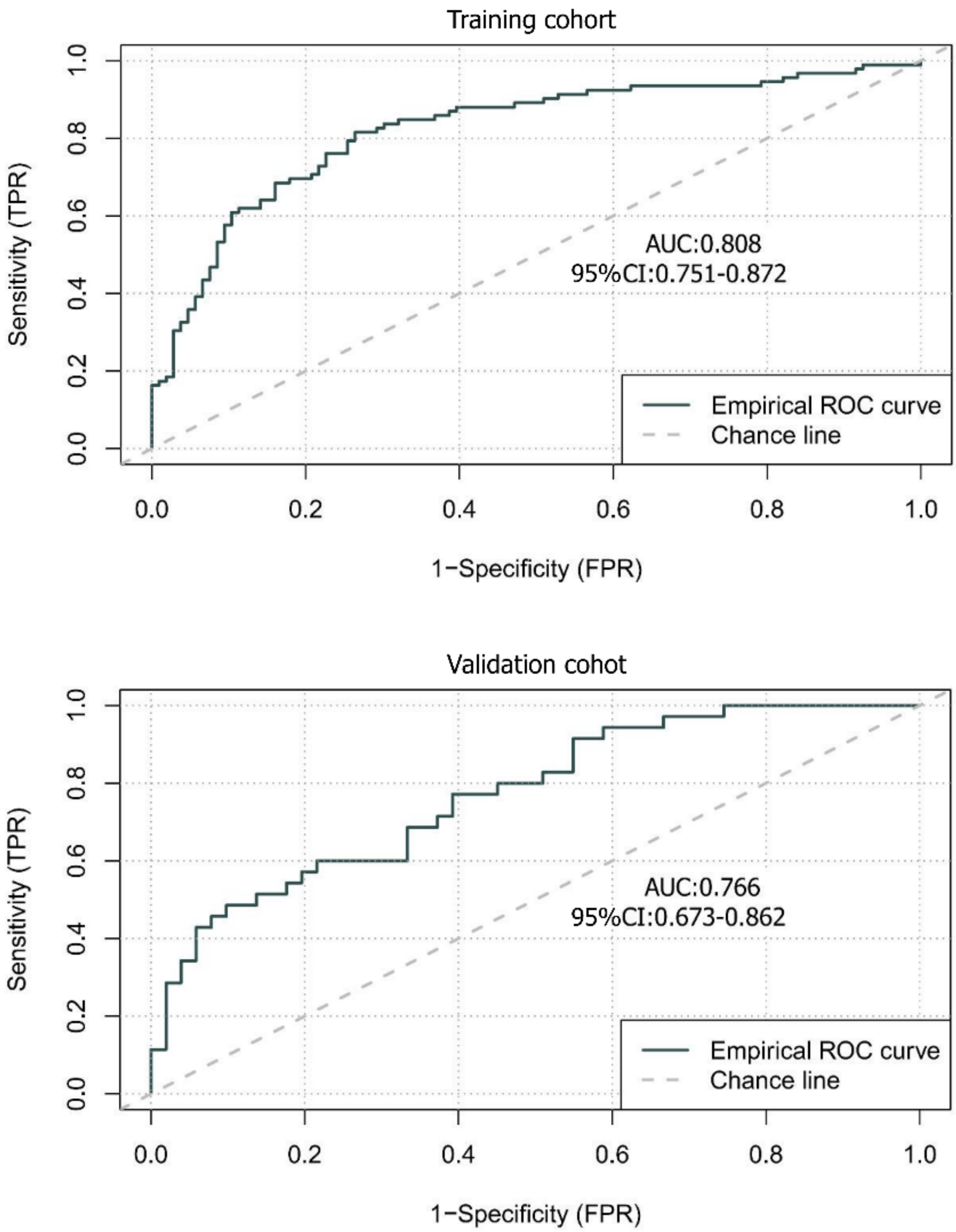

Fig. 2. Receiver operating characteristic (ROC) curves for nomogram on the training and validation sets. TPR, true positive rate; FPR, false positive rate; AUC, area under the curve.

model and increase its predictive power. The clinical utility of nomograms has been increasingly recognized in urology. For instance, Yang et al (2023) developed a clinical machine-learning nomogram based on peripheral lymphocyte functional subsets to predict prostate cancer risk stratification. Similarly, our nomogram provides a reliable preoperative assessment tool, enabling clinicians to identify high-risk patients and tailor their surgical approach accordingly. Other studies have also emphasized the importance of various factors in managing hematospermia. For example, Zaidi et al (2019) discussed the etiology, diagnosis, and management

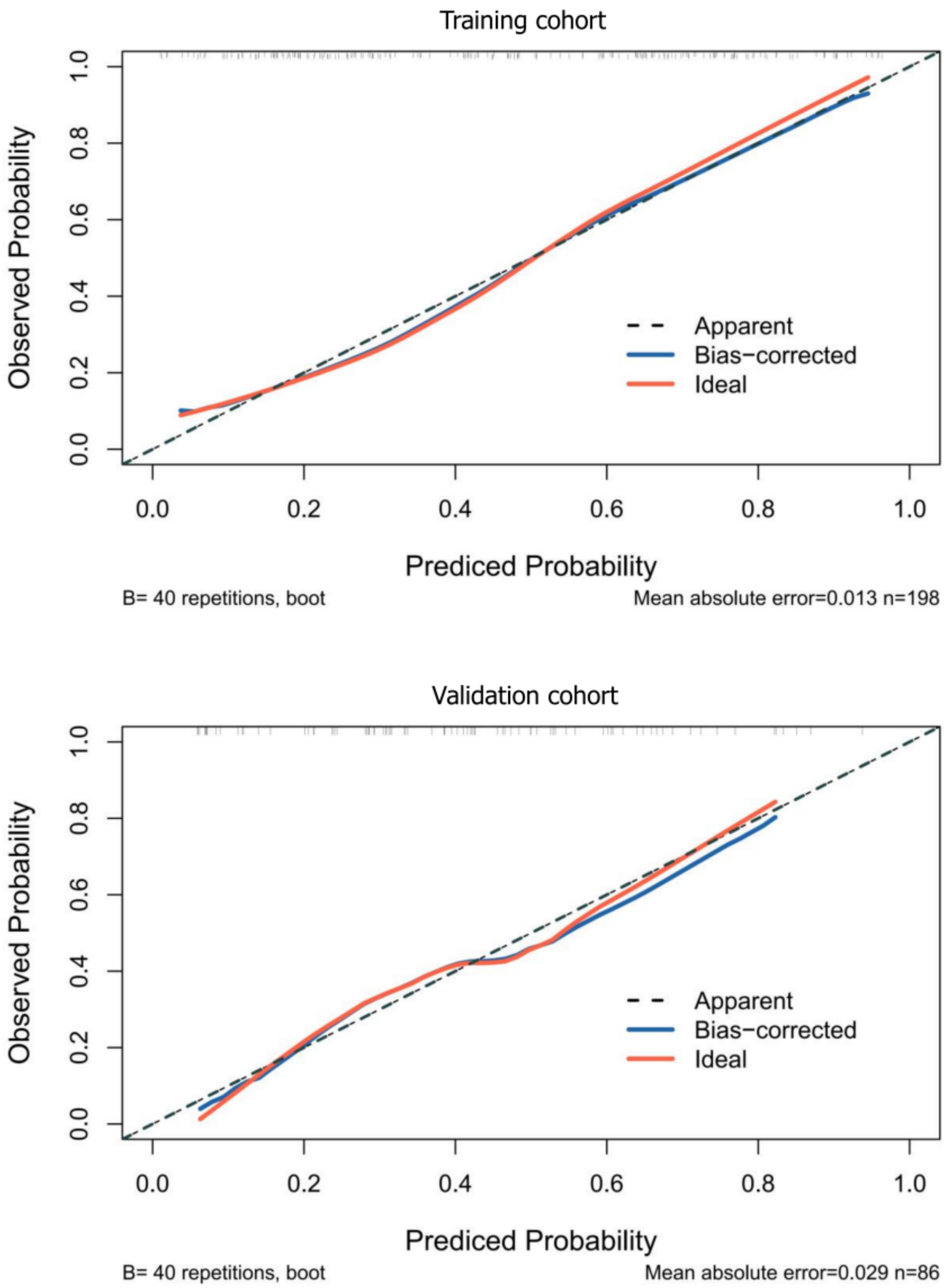

Fig. 3. Calibration curves for evaluating prediction accuracy of nomogram on the training and validation sets.

of seminal vesicle stones, highlighting that structural abnormalities in the seminal vesicles can contribute to hematospermia and its recurrence. Suh et al (2017) provided a comprehensive review of the classification, evaluation, and management of hematospermia, emphasizing the need for accurate diagnostic tools to improve treatment outcomes. These findings support our approach of using a multifactorial model to predict the presence of translucent membranes, thereby aiding in more ef-

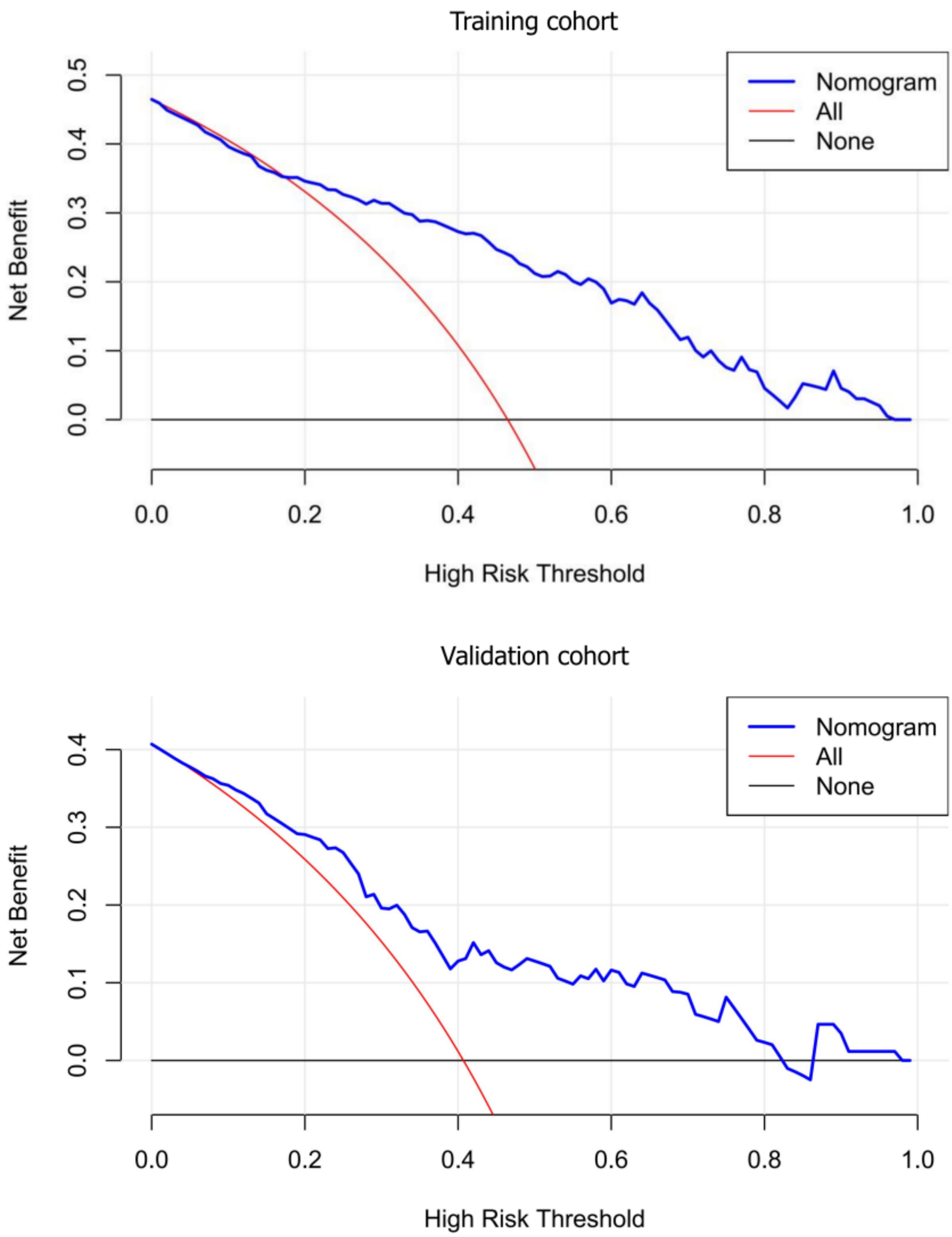

Fig. 4. Decision curve analysis for evaluating clinical net benefits of nomograms on the training and validation sets.

fective management strategies. Integrating the nomogram into clinical workflows (Xia et al, 2023; Xie et al, 2023; Zhang et al, 2022) can significantly enhance the management of hematospermia patients. It can be used as a preoperative assessment tool to identify patients at high risk of having translucent membranes in the prostatic utricle. By incorporating this predictive model into the initial patient evaluation process, urologists can better plan for the surgical procedure, select the most appropriate surgical approach, and prepare the necessary equipment to manage the translucent membranes effectively. This preoperative risk stratification can reduce operative time and complexity, thereby minimizing complications and improving surgical outcomes. Additionally, the use of the nomogram can facilitate more informed discussions with patients regarding their treatment options and expected outcomes, leading to improved patient satisfaction and adherence to treatment plans. In the long term, incorporating such predictive tools into routine clinical practice can contribute to developing personalized treatment strategies, optimizing resource allocation, and enhancing overall healthcare efficiency. The nomogram effectively predicts translucent membranes in the prostatic utricle, with ROC areas of 0.808 in the training set and 0.766 in the validation set. Calibration curves show strong alignment between predictions and outcomes, and the DCA confirms its clinical benefit.

This study has several limitations that must be acknowledged. First, incorporating a limited number of risk factors in our model may have excluded potential variables that could influence the presence of translucent membranes. Future studies should consider a broader range of variables, including patient lifestyle habits and relevant biomarkers, to enhance the comprehensiveness and predictive power of the model. Second, the study's retrospective nature may have introduced selection bias and limited the ability to control for all potential confounders. Prospective studies are warranted to further validate the findings and enhance the nomogram's reliability. Third, the sample size, though adequate for internal validation, was relatively small for robust external validation. A larger, multicenter cohort would be ideal to confirm the predictive accuracy and clinical utility of the nomogram across diverse patient populations.

Moreover, the analysis of misclassified cases, such as false positives and false negatives, revealed that certain variables may have a stronger influence in specific patient subgroups, suggesting the need for further refinement of the model. For instance, certain comorbidities or variations in imaging techniques could contribute to these discrepancies. Addressing these factors in future research could help improve the model's overall accuracy and reduce the rate of misclassification.

Finally, while our study included internal validation of the nomogram using a randomly divided cohort from the same patient database, more consideration of its applicability to different populations needs to be considered. Unfortunately, due to logistical and resource constraints, we could not incorporate an external validation cohort from other institutions. Despite this limitation, the current nomogram provides a promising tool for predicting the presence of translucent membranes in patients with hematospermia. Future research should include external validation cohorts to strengthen the evidence for its clinical application.

In summary, despite its limitations, this nomogram represents a promising tool for predicting the presence of translucent membranes in patients with hematospermia, with the potential for significant clinical impact. Further studies are needed to refine the model and confirm its utility across broader patient populations.

Conclusion

This study successfully identified clinical and radiological factors associated with the manifestation of translucent membranes in patients with hematospermia and developed a nomogram to predict their presence in the prostatic utricle. The implementation of this prognostic model is expected to assist healthcare practitioners in making informed decisions regarding surgical interventions and tailored therapeutic strategies, enhancing personalized patient care. Further research is warranted to explore additional potential factors influencing the occurrence of these membranes.

Key Points

- Innovative Predictive Nomogram: This study presents a novel nomogram model specifically developed to predict the presence of translucent membranes in the prostatic utricle of hematospermia patients. The model leverages comprehensive clinical and radiological data, significantly advancing urological diagnostics.
- Identification of Key Risk Factors: Through multivariable logistic regression analysis, the study identifies critical independent risk factors for the presence of translucent membranes. These factors include age, disease duration, seminal vesicle width, length, thickness, and a history of seminal vesiculitis.
- High Predictive Accuracy: The nomogram exhibits excellent predictive capability, as evidenced by area under the curve (AUC) values of 0.808 for the training set and 0.766 for the validation set. This underscores the model's robust discriminative power and reliability.
- Clinical Utility and Net Benefit: DCA demonstrates that the nomogram provides significant clinical net benefits, aiding healthcare practitioners in making informed decisions regarding surgical interventions and personalized therapeutic strategies for patients with hematospermia.
- Model Validation and Consistency: Calibration curves for both the training and validation sets reveal a high level of agreement between predicted and observed results, highlighting the model's accuracy and consistency in predicting the occurrence of translucent membranes.

Availability of Data and Materials

The data that support the findings of the study are available from the corresponding author upon reasonable request.

Author Contributions

LW, YZ and JJ designed the research. LW performed the software and validation tasks. YZ was responsible for resources, visualization, data curation, and validation. ZW and ZJ conducted the investigation, formal analysis, and validation.

MS and ML reviewed medical records and curated data. ZH provided help and advice on the data analysis. JJ drafted the manuscript. 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

This retrospective study was approved by the Ethics Committees of The Second People's Hospital of Hefei and adhered to the ethical principles outlined in the Declaration of Helsinki [approval number: 2024-KY-011]. Written informed consent was obtained from the patients.

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Conflict of Interest

The authors declare no conflict of interest.

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