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ORIGINAL RESEARCH

Development and Validation of a Predictive Model for Postoperative Nausea and Vomiting in Thyroid Cancer Patients: A Retrospective Case-Control Study

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Background: Thyroid cancer is the most prevalent endocrine malignancy, with surgical intervention being the primary treatment modality. Postoperative nausea and vomiting (PONV) are common complications following thyroid surgery, significantly impacts patient recovery. Consequently, this study analyzed the risk factors for PONV in patients with thyroid cancer post-surgery and developed a predictive model.

Methods: This retrospective study involved 393 patients who underwent thyroid cancer surgery at a tertiary-level Class A hospital between July 2024 and February 2025. The patients were randomly divided into a training set (n=275) and a validation set (n=118). A predictive model was constructed using multivariate logistic regression analysis, and a nomogram was developed. The model's discrimination was evaluated using receiver operating characteristic (ROC) curves, while calibration was assessed through calibration curves, and clinical applicability was determined via decision curve analysis (DCA).

Results: The overall incidence of postoperative nausea and vomiting (PONV) was found to be 29.01%. The final predictive model developed from the training set incorporated four variables: age (≥50 years), a history of PONV or motion sickness, non-use of ondansetron, and a delay in the time to first oral intake (> 6 hours). The area under the curve (AUC) values for the training and validation sets were 0.76 and 0.68, respectively. Additionally, the calibration curves for both sets exhibited strong consistency. Furthermore, the decision curve analysis (DCA) results indicated good clinical applicability for both the training and validation sets.

Conclusion: Patients with thyroid cancer exhibit a heightened risk of postoperative nausea and vomiting, which correlates with age, a history of PONV or motion sickness, the administration of ondansetron, and the time to first oral intake. The PONV prediction model constructed using these variables demonstrates favourable discriminatory ability, calibration, and clinical utility.

Keywords: thyroid cancer, postoperative nausea and vomiting, risk prediction model, regression analysis

Introduction

Thyroid cancer is a malignant tumor that arises from the epithelial cells of thyroid follicles or parafollicular cells. It is the most prevalent malignancy of the endocrine system globally, ranking seventh in incidence among all cancers worldwide.[1] According to the 2022 Global Cancer Statistics, there were approximately 821,173 new cases of thyroid cancer reported globally. However, its mortality rate remains relatively low, accounting for about 0.5% of all cancer deaths, which reflects its generally favorable prognosis.[2] The occurrence and progression of this disease are associated with multiple factors, including unmodifiable factors such as gender and genetic susceptibility, as well as modifiable risk factors like obesity and radiation exposure.[3,4] Currently, surgical resection remains the primary curative treatment for thyroid cancer, with the specific surgical

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approach determined by tumor staging and patient clinical characteristics.[5,6] Notably, Li et al[7] demonstrated that patients with low-risk papillary thyroid microcarcinoma (tumor size ≤ 10 mm) derive limited therapeutic benefit from surgery, suggesting that surgeons should exercise greater caution when considering surgical intervention for these patients. However, surgical treatment inevitably carries a range of complications. In addition to hypocalcemia, hemorrhage, and vocal cord paralysis, postoperative nausea and vomiting are also common complications. The hyperextended neck position specific to thyroid surgery, together with surgical manipulation in the cervical region that may stimulate receptors in the vomiting center, the vagus nerve, and/or the glossopharyngeal nerve, results in an extremely high incidence of postoperative nausea and vomiting (PONV) (60–80%)[8] in patients under general anesthesia, which significantly compromises patient experience and post-operative recovery. Postoperative nausea and vomiting (PONV) refers to the occurrence of nausea and vomiting within 24 hours following surgery and is one of the most common adverse reactions postoperatively.[9] Reports indicate that the incidence of PONV in general surgery ranges from 20% to 30%, and can escalate to 70% to 80% in the absence of preventive measures.[10] For patients undergoing thyroid cancer surgery, PONV not only results in significant physical and psychological discomfort but may also lead to severe complications such as dehydration, electrolyte imbalance, wound dehiscence, bleeding, and aspiration pneumonia. These complications pose direct threats to patient safety and can impede postoperative recovery.[11] Therefore, effective prevention and management of PONV are essential for enhancing perioperative outcomes in patients undergoing thyroid cancer surgery.

Currently, the prediction of PONV risk predominantly relies on generic assessment tools such as the Apfel score. However, the model's variables—including female gender, non-smoking status, history of PONV, and motion sickness—do not account for specific risk factors associated with thyroid surgery, leading to limited predictive efficacy in specialized clinical settings. Existing studies have primarily concentrated on analyzing factors influencing PONV,[12] while quantitative predictive models for thyroid PONV remain scarce both domestically and internationally. In China, Zhao et al[13] identified independent risk factors for PONV in thyroid surgery through logistic regression analysis: absence of a smoking history, presence of a PONV history, combined intravenous and inhalation anesthesia, and non-prophylactic use of dexamethasone. They constructed a predictive model with a C-index of 0.787 (95% CI: 0.711–0.863). However, this study was limited by a small sample size and faced multicollinearity issues between gender and smoking history, which may compromise the accuracy of the conclusions. Furthermore, Zhang et al[14] noted that the Modified Frailty Index (mFI) is a significant predictor of PONV in patients undergoing thyroid cancer surgery. Nevertheless, assessing mFI is not straightforward; it requires a systematic review of medical records or an inquiry into multiple aspects of the patient's medical history, which limits accessibility and ease of use. In summary, developing a practical PONV risk prediction model for patients undergoing thyroid cancer surgery is of significant clinical importance. This study aims to develop and internally validate a comprehensive risk prediction model using retrospective case data. The successful establishment of this model will provide clinicians with a quantitative tool for early identification of high-risk patients and for implementing individualized prevention strategies. Ultimately, this will achieve the goal of optimizing postoperative recovery quality and improving clinical outcomes.

Methods

Sample-Size Estimation

This study employed the events per variable (EPV) method to calculate the sample size, ensuring that each variable had at least 10 outcome events to guarantee accuracy.[15] Previous studies have reported a postoperative nausea and vomiting (PONV) incidence of approximately 30% in patients with thyroid cancer.[10] The predictive model was expected to incorporate five or fewer predictors, resulting in a required sample size of $N = (5 \times 10) / 0.3 = 167$ for this study. The sample size of human subjects in the training set of this study (N = 275) exceeds the minimum required by the EPV method, thereby promising reliable estimates.

Study Population

This retrospective case-control study retrospectively collected data on 393 thyroid cancer patients who underwent partial, subtotal, or total thyroidectomy (open or endoscopic) at Yichang Central People's Hospital between July 2024 and February 2025. Following surgery, patients received routine nursing care guided by the enhanced recovery after surgery (ERAS) principles. After complete emergence from general anesthesia and achievement of stable vital signs, patients were provided with pillows and allowed to drink a small amount of water. If no choking cough, nausea, or vomiting was observed at 6 hours postoperatively, a cool, then tepid, liquid diet was initiated, gradually advanced to a semi-liquid diet, then a soft diet, and finally a regular diet. Conscious patients were instructed to perform leg flexion-extension exercises and turn over in bed. Early ambulation was encouraged starting on postoperative day 1. Meanwhile, the primary nurses closely monitored for complications, including pain, nausea, vomiting, and incisional hemorrhage, implemented timely interventions, and documented all relevant findings.

Inclusion Criteria

1. Age ≥ 18 years.
2. Elective partial, subtotal, or total thyroidectomy (open or endoscopic).
3. Inhalation-sedation combined general anesthesia.
4. No opioid medications were administered within 24 hours postoperatively.
5. Pathological diagnosis of thyroid cancer.

Exclusion Criteria

1. Age < 18 years.
2. Patients with a history of psychiatric disorders.
3. Use of antiemetic medication within 24 hours prior to surgery.
4. Concurrent gastrointestinal dysfunction.
5. Pregnancy or lactation.

Observation Index

The variables collected in this study include: age, gender, smoking status, history of pregnancy-related vomiting, history of PONV or motion sickness, hypertension, diabetes, cervical spondylosis, heart disease, ondansetron, dexamethasone, duration of surgery, time to first oral intake, and occurrence of PONV within 24 hours postoperatively. Detailed definitions of all variables are provided in Appendix 1. PONV was assessed regularly by trained ward nurses within 24 hours postoperatively. Assessments were performed at 1, 6, 12, and 24 hours after surgery, with additional ad hoc assessments conducted as needed based on patient-reported symptoms. We adopted a combined approach of active inquiry and systematic observation: nurses proactively inquired about nausea in patients, while simultaneously monitoring for retching or vomiting. An episode of nausea, retching, or vomiting was documented as PONV positivity if it was identified during routine nursing rounds or reported by the patient upon inquiry, even in the absence of spontaneous patient reporting. For this study, PONV positivity was defined as the presence of any of the aforementioned clinical symptoms (nausea, retching, or vomiting) within 24 hours postoperatively.

Data-Collection Methods

Data for this study were collected through a retrospective review of the hospital's electronic medical record system and anesthesia information system. Data extraction was performed independently by two researchers who completed standardized training. To ensure consistency in variable definitions and extraction criteria, we developed a detailed data extraction protocol and provided specialized training. To minimize measurement bias, the core of this study lies in separating the collection of predictive factors from the assessment of PONV outcomes, while implementing blinding for relevant personnel. The specific procedure is as follows: One researcher is responsible for collecting patients' baseline characteristics, surgical procedures, medication use, and other predictor variables. However, all records related to PONV in the medical records accessed by this researcher are masked, meaning this group is blinded to the study outcome. Meanwhile, another investigator, who was unaware of any baseline patient information, independently assessed PONV outcomes based solely on postoperative care and medication records, thereby maintaining blinding to the predictor variables. Finally, a principal investigator not involved in the aforementioned process will merge and analyze the de-identified predictor variable dataset with the outcome assessment dataset. This process ensures the independence of variable extraction and outcome determination, enhancing the reliability and robustness of the model in this study. Cases of thyroid cancer surgery (N=407) from Yichang Central People's Hospital between July 2024 and February 2025 were

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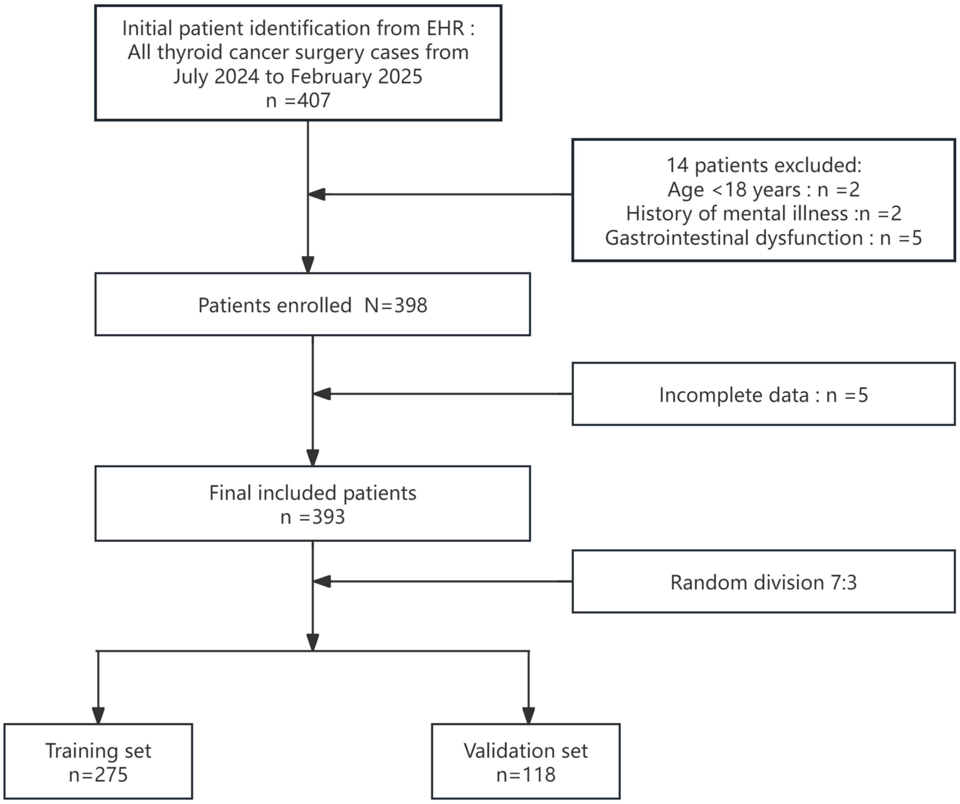

Figure 1 The case inclusion flowchart.

extracted from the electronic medical record system and screened in stages according to inclusion/exclusion criteria. Excluded cases included 2 patients under 18 years of age, 2 with a history of psychiatric disorders, 5 with gastrointestinal dysfunction, and 5 with incomplete data. The final cohort of 393 patients was randomly split into a training set and a validation set at a 7:3 ratio. The case inclusion flowchart is shown in Figure 1.

Statistical Analysis

Statistical analysis was conducted using SPSS 26.0 software. Quantitative data were summarized using means and standard deviations, while qualitative data were presented as case numbers and percentages. Univariate analysis within the training set utilized chi-square tests for statistical evaluation. Variables that demonstrated statistical significance in the chi-square analysis were subsequently subjected to logistic regression analysis to construct predictive models.

Use R software to plot ROC curves, calibration curves, and DCA curves. The level of statistical significance was set at $\alpha < 0.05$.

Ethics Approval

This study was approved by the Ethics Committee of Yichang Central People's Hospital (2025-349-01) and exempted from informed consent. After extraction by the Information Section, independent statisticians remove direct identifiers and generate research codes. The analyzed dataset does not contain sensitive information such as names or hospital ID numbers. The original data is retained by the researcher themselves, and the findings of this study cannot be linked to individual patients. All methods were performed in accordance with the Declaration of Helsinki and the relevant guidelines and regulations.

Results

Baseline Patient Characteristics

This study included 393 patients who underwent thyroid cancer surgery, revealing an overall incidence of postoperative nausea and vomiting (PONV) of 29.01%. As presented in Table 1, the training set (n = 275) and the validation set (n = 118) demonstrated statistically significant differences solely in the history of nausea and vomiting during pregnancy (P = 0.037). No statistically significant differences were found for other variables, including vomiting, age, gender, smoking status,

Table 1 Comparison of Training and Validation Set Materials

Variables	Total (n = 393)	Test (n = 118)	Train (n = 275)	Statistic	*P*
Occurrence of PONV within 24 hours, n (%)				χ^2=1.05	0.305
No	279 (70.99)	88 (74.58)	191 (69.45)		
Yes	114 (29.01)	30 (25.42)	84 (30.55)		
Age(years), n (%)				χ^2=0.58	0.446
<50	208 (52.93)	59 (50.00)	149 (54.18)		
≥50	185 (47.07)	59 (50.00)	126 (45.82)		
Gender, n (%)				χ^2=0.00	0.996
Female	323 (82.19)	97 (82.20)	226 (82.18)		
Male	70 (17.81)	21 (17.80)	49 (17.82)		
Smoking status, n (%)				χ^2=2.10	0.147
No	370 (94.15)	108 (91.53)	262 (95.27)		
Yes	23 (5.85)	10 (8.47)	13 (4.73)		
History of pregnancy-related vomiting, n (%)				χ^2=4.37	0.037
No	300 (76.34)	82 (69.49)	218 (79.27)		
Yes	93 (23.66)	36 (30.51)	57 (20.73)		
History of PONV or motion sickness, n (%)				χ^2=0.62	0.431
No	287 (73.03)	83 (70.34)	204 (74.18)		
Yes	106 (26.97)	35 (29.66)	71 (25.82)		
Hypertension, n (%)				χ^2=0.24	0.626
No	331 (84.22)	101 (85.59)	230 (83.64)		
Yes	62 (15.78)	17 (14.41)	45 (16.36)		
Diabetes, n (%)				χ^2=0.05	0.824
No	368 (93.64)	110 (93.22)	258 (93.82)		
Yes	25 (6.36)	8 (6.78)	17 (6.18)		
Cervical spondylosis, n (%)				χ^2=2.36	0.124
No	365 (92.88)	106 (89.83)	259 (94.18)		
Yes	28 (7.12)	12 (10.17)	16 (5.82)		
Heart disease, n (%)				χ^2=0.11	0.743
No	389 (98.98)	116 (98.31)	273 (99.27)		
Yes	4 (1.02)	2 (1.69)	2 (0.73)		
Ondansetron, n (%)				χ^2=0.16	0.689
Not used	98 (24.94)	31 (26.27)	67 (24.36)		
Used	295 (75.06)	87 (73.73)	208 (75.64)		
Dexamethasone, n (%)				χ^2=0.59	0.444
Not used	269 (68.45)	84 (71.19)	185 (67.27)		
Used	124 (31.55)	34 (28.81)	90 (32.73)		
Duration of surgery, n (%)				χ^2=0.01	0.918
<3h	311 (79.13)	93 (78.81)	218 (79.27)		
≥3h	82 (20.87)	25 (21.19)	57 (20.73)		
Time to first oral intake, n (%)				χ^2=0.00	0.975
≤6h	350 (89.06)	105 (88.98)	245 (89.09)		
>6h	43 (10.94)	13 (11.02)	30 (10.91)		

Note: χ^2: Chi-square test.
Abbreviation: PONV, postoperative nausea and vomiting.

history of PONV or motion sickness, hypertension, diabetes, cervical spondylosis, heart disease, ondansetron, dexamethasone, duration of surgery, time to first oral intake (P > 0.05). This finding indicates that the two groups are comparable regarding these baseline characteristics.

Univariate Analysis of Postoperative Nausea and Vomiting in Thyroid Cancer Patients in the Training Set

Univariate analysis of the training set (Table 2) showed statistically significant differences in age, gender, history of PONV or motion sickness, ondansetron administration, surgery duration, and time to first oral intake (P < 0.05). Smoking

Table 2 Risk Factor Analysis of Postoperative Nausea and Vomiting in Thyroid Cancer Patients

Variables	Total (n = 275)	0 (n = 191)	1 (n = 84)	Statistic	*P*
Age(years), n (%)				χ^2=5.00	0.025
<50	149 (54.18)	112 (58.64)	37 (44.05)		
≥50	126 (45.82)	79 (41.36)	47 (55.95)		
Gender, n (%)				χ^2=4.17	0.041
Female	226 (82.18)	151 (79.06)	75 (89.29)		
Male	49 (17.82)	40 (20.94)	9 (10.71)		
Smoking status, n (%)				χ^2=0.08	0.771
No	262 (95.27)	181 (94.76)	81 (96.43)		
Yes	13 (4.73)	10 (5.24)	3 (3.57)		
History of pregnancy-related vomiting, n (%)				χ^2=3.26	0.071
No	218 (79.27)	157 (82.20)	61 (72.62)		
Yes	57 (20.73)	34 (17.80)	23 (27.38)		
History of PONV or motion sickness, n (%)				χ^2=20.98	<0.001
No	204 (74.18)	157 (82.20)	47 (55.95)		
Yes	71 (25.82)	34 (17.80)	37 (44.05)		
Hypertension, n (%)				χ^2=2.27	0.132
No	230 (83.64)	164 (85.86)	66 (78.57)		
Yes	45 (16.36)	27 (14.14)	18 (21.43)		
Diabetes n (%)				χ^2=0.19	0.661
No	258 (93.82)	180 (94.24)	78 (92.86)		
Yes	17 (6.18)	11 (5.76)	6 (7.14)		
Cervical spondylosis, n (%)				χ^2=0.047	0.829
No	259 (94.18)	179 (93.71)	80 (95.23)		
Yes	16 (5.82)	12 (6.28)	4 (4.76)		
Heart disease, n (%)				–	0.518
No	273 (99.27)	190 (99.48)	83 (98.81)		
Yes	2 (0.73)	1 (0.52)	1 (1.19)		
Ondansetron, n(%)				χ^2=8.46	0.004
Not used	67 (24.36)	37 (19.37)	30 (35.71)		
Used	208 (75.64)	154 (80.63)	54 (64.29)		
Dexamethasone, n (%)				χ^2=1.57	0.21
Not used	185 (67.27)	124 (64.92)	61 (72.62)		
Used	90 (32.73)	67 (35.08)	23 (27.38)		
Duration of surgery, n (%)				χ^2=4.29	0.038
<3h	218 (79.27)	145 (75.92)	73 (86.90)		
≥3h	57 (20.73)	46 (24.08)	11 (13.10)		
Time to first oral intake, n (%)				χ^2=20.71	<0.001
≤6h	245 (89.09)	181 (94.76)	64 (76.19)		
>6h	30 (10.91)	10 (5.24)	20 (23.81)		

Notes: χ^2: Chi-square test, –: Fisher exact.
Abbreviation: PONV, postoperative nausea and vomiting.

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status, pregnancy-related vomiting history, hypertension, diabetes, cervical spondylosis, heart disease, and dexamethasone showed no significant differences ($P > 0.05$).

Multivariate Analysis of Postoperative Nausea and Vomiting in Thyroid Cancer Patients in the Training Set

A multivariate logistic regression analysis was conducted on the statistically significant variables identified in the univariate analysis. A stepwise method was employed for independent variable screening, the results indicated that age, a history of PONV or motion sickness, the administration of ondansetron, the time to first oral intake were statistically significant risk factors for PONV in patients with thyroid cancer ($P < 0.05$) (Table 3).

Development of a Predictive Model for Postoperative Nausea and Vomiting in Thyroid Cancer Patients Using a Training Dataset

Based on the analysis conducted, we identified four significant risk factors for PONV: age, history of PONV or motion sickness, administration of ondansetron, and the time to first oral intake. The logistic regression equation formulated from these risk factors is expressed as $P = 1 / (1 + e^{-Y})$, where e represents the base of the natural logarithm, and Y is defined by the equation $Y = 0.66 \times \text{age} + 1.3 \times (\text{history of PONV or motion sickness}) - 1.07 \times \text{ondansetron} + 2.04 \times (\text{time to first oral intake}) - 1.02$. Using R software, we visualized the data as a scatterplot, with each of the four predictor variables represented accordingly. In the operational procedure, a vertical line is first drawn upward from the specific score point of the patient's predictor variable. The score corresponding to the intersection of this line with the Point line segment denotes the actual score for that variable. Likewise, the total score predicted by the patient model is obtained by summing the scores corresponding to the intersection points of the four predictors with the Point line segment. Subsequently, the total score is located within the Total Points section, and a vertical line is drawn downward. The numerical value at the intersection of this line and the Risk point signifies the probability of the patient experiencing the outcome event (Figure 2).

Evaluation of Distinctiveness Between Training and Validation Sets

This study evaluates the model's discrimination capability using metrics such as AUC and accuracy. ROC curves were plotted for both the training set (Figure 3) and validation set (Figure 4). The training set AUC was 0.76, exceeding 0.7, while the validation set AUC was 0.68, approaching 0.7. This indicates the model demonstrates good discrimination capability across both datasets. Detailed metrics are presented in Table 4.

Table 3 Multivariate Logistic Regression Analysis of Postoperative Nausea and Vomiting in Thyroid Cancer Patients

Variables	**β**	**S.E.**	**Z**	***P***	**OR (95% CI)**
Intercept	−1.02	0.32	−3.20	0.001	0.36 (0.19 ~ 0.67)
Age(years)					
<50					1.00 (Reference)
≥50	0.66	0.29	2.25	0.024	1.94 (1.09 ~ 3.45)
History of PONV or motion sickness					
No					1.00 (Reference)
Yes	1.30	0.31	4.14	<0.001	3.67 (1.99 ~ 6.80)
Ondansetron					
Not used					1.00 (Reference)
Used	−1.07	0.32	−3.30	<0.001	0.34 (0.18 ~ 0.65)
The time to first oral intake					
≤6h					1.00 (Reference)
>6h	2.04	0.45	4.52	<0.001	7.66 (3.17 ~ 18.51)

Abbreviations: OR, odds ratio; PONV, postoperative nausea and vomiting.

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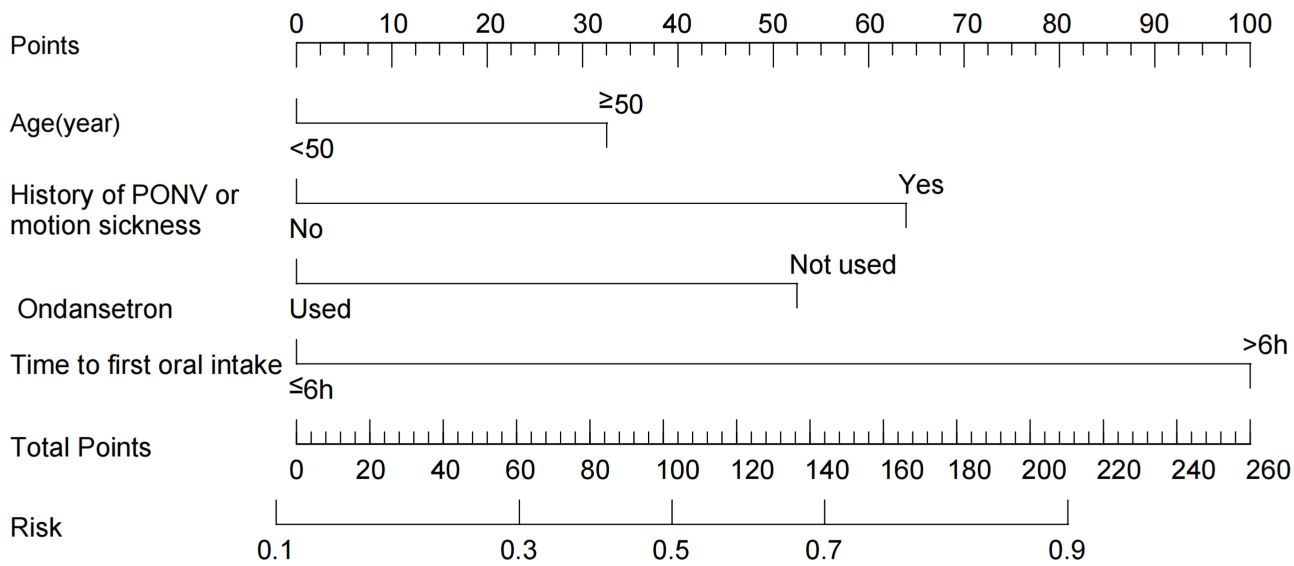

Figure 2 Nomogram for Postoperative Nausea and Vomiting in Thyroid Cancer Patients.

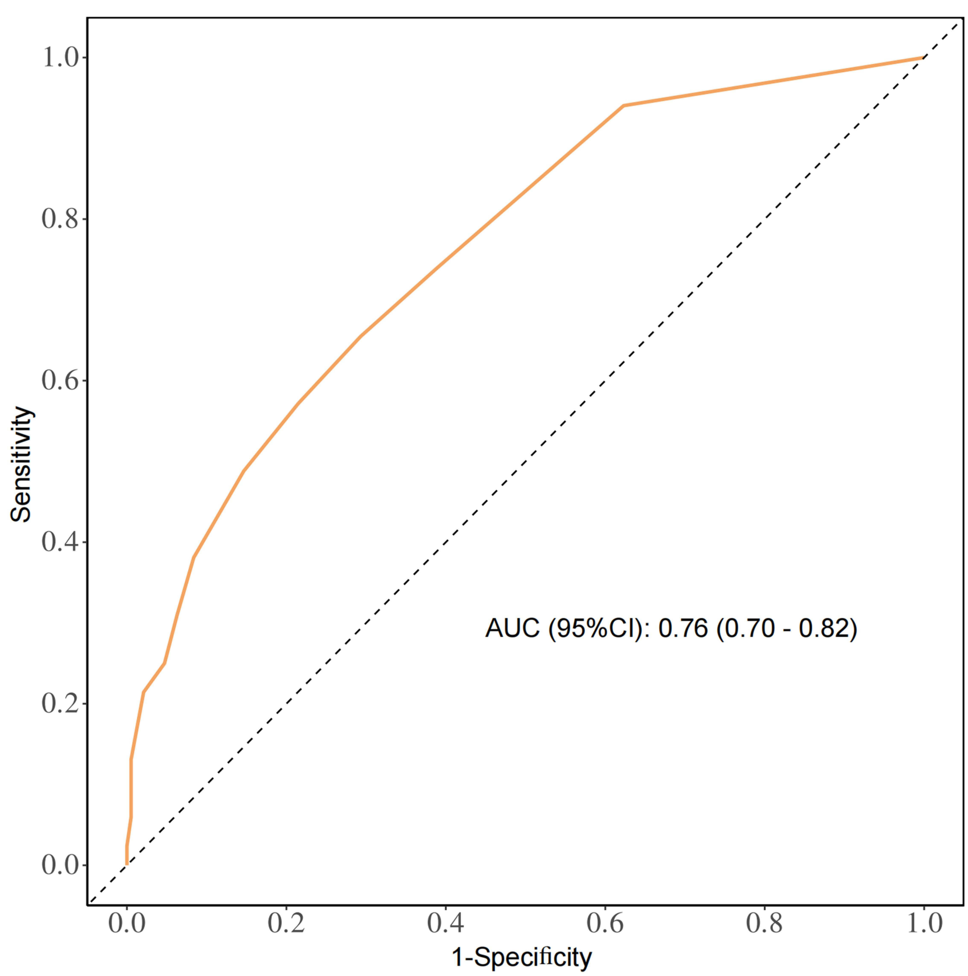

Figure 3 Training Set ROC Curve Plot.

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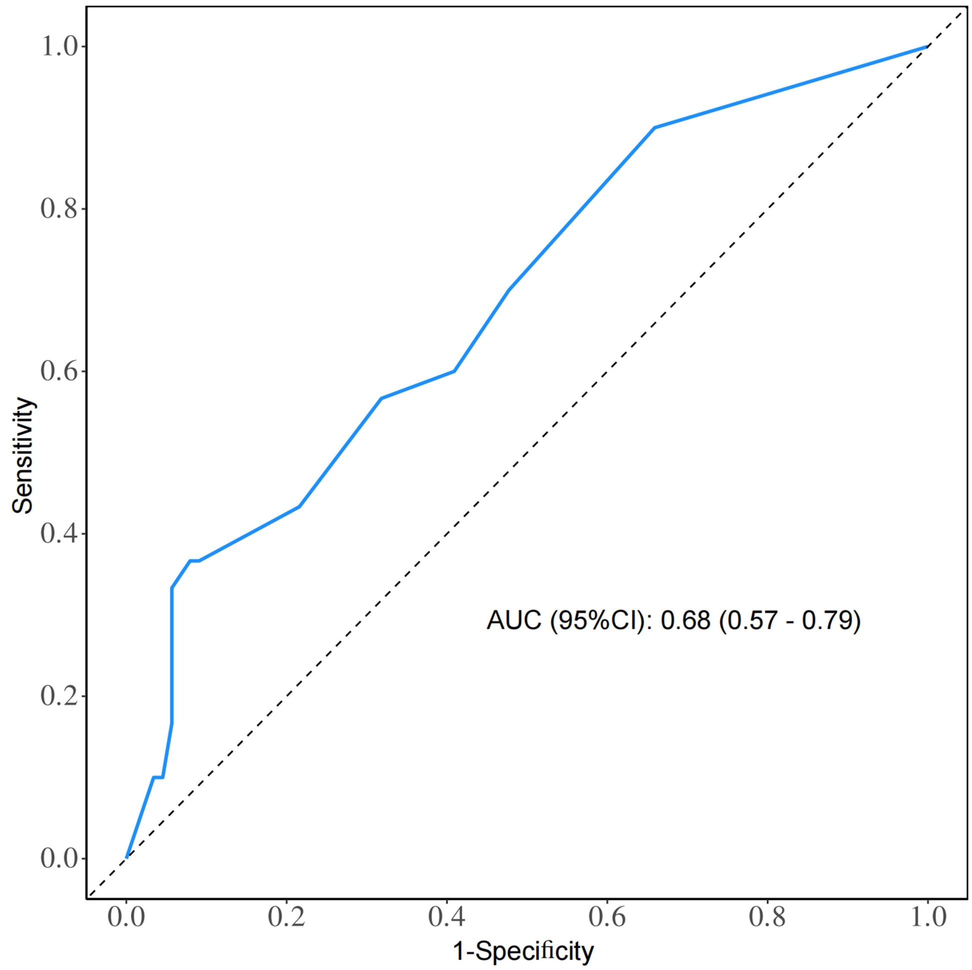

Figure 4 Validation Set ROC Curve Plot.

Calibration Assessment of Training and Validation Sets

The model's calibration was assessed using the Hosmer–Lemeshow test and calibration curves. The P-values from the H–L test for the training and validation sets were 0.934 and 0.316, respectively, both exceeding 0.05. The calibration curve for the training set (Figure 5) closely follows the reference diagonal line, indicating a high alignment between the model's predicted risks and the actual observed risks. However, there is a slight overestimation of predicted values compared to actual values in the low-to-medium risk range. In the validation set (Figure 6), the model shows a slight systematic overestimation in the medium-to-high risk range. The combined results of the H–L test and calibration curve suggest a good consistency between the predicted probabilities of outcome events and the actual probabilities of occurrence, demonstrating that the model fits well.

Table 4 Related Indicators of Model Discrimination

Data	AUC (95% CI)	Accuracy (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Cut Off
Train	0.76 (0.70–0.82)	0.69 (0.63–0.75)	0.71 (0.64–0.77)	0.65 (0.55–0.76)	0.82 (0.76–0.88)	0.50 (0.40–0.59)	0.29
Test	0.68 (0.57–0.79)	0.59 (0.50–0.68)	0.59 (0.49–0.69)	0.60 (0.42–0.78)	0.81 (0.72–0.91)	0.33 (0.21–0.46)	0.29

Abbreviations: AUC, area under the curve; CI, c-index; PPV, positive predictive value; NPV, negative predictive value.

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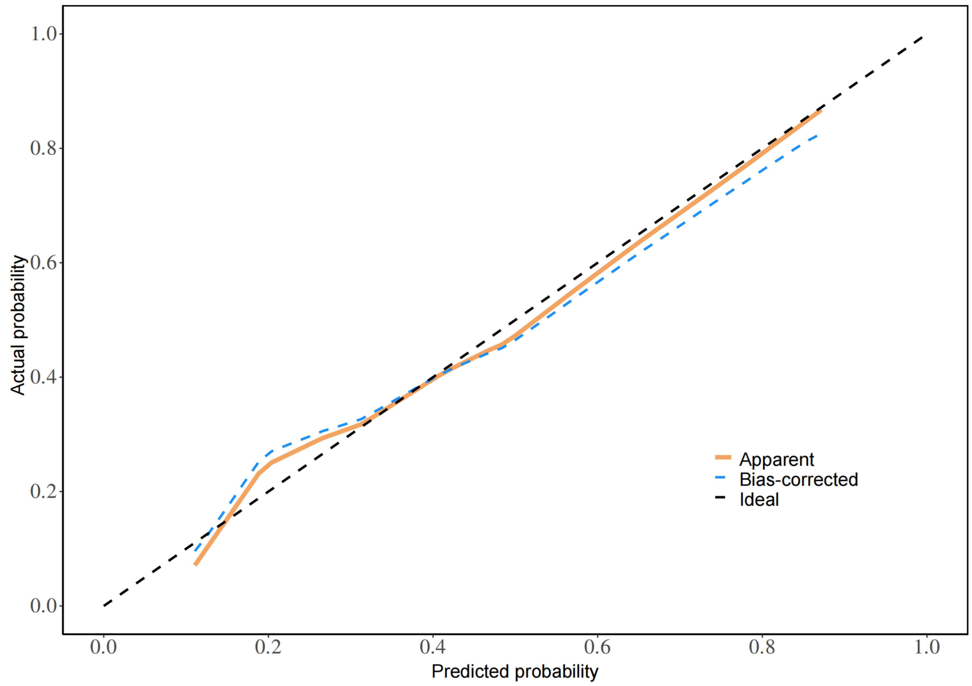

Figure 5 Training Set Calibration Curve Plot.

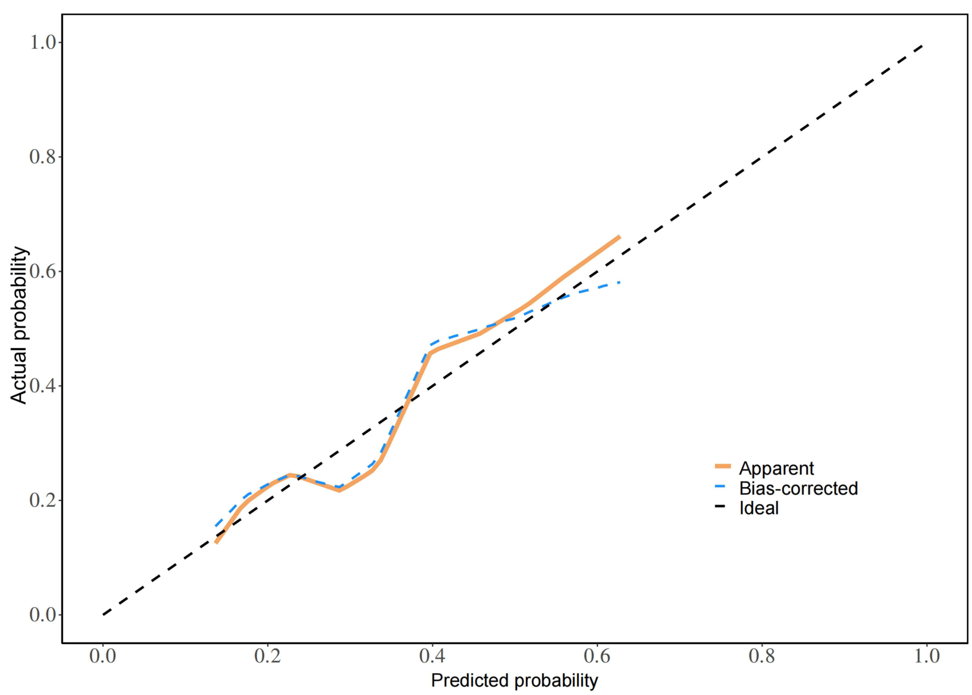

Figure 6 Validation Set Calibration Curve Plot.

Assessment of Clinical Applicability of Training and Validation Sets

Clinical decision curve analysis (Figures 7 and 8) further validated the model's clinical utility. Within the threshold probability range of 0.1 to 0.95 on the training set DCA curve, the net benefit of utilizing the model to guide PONV

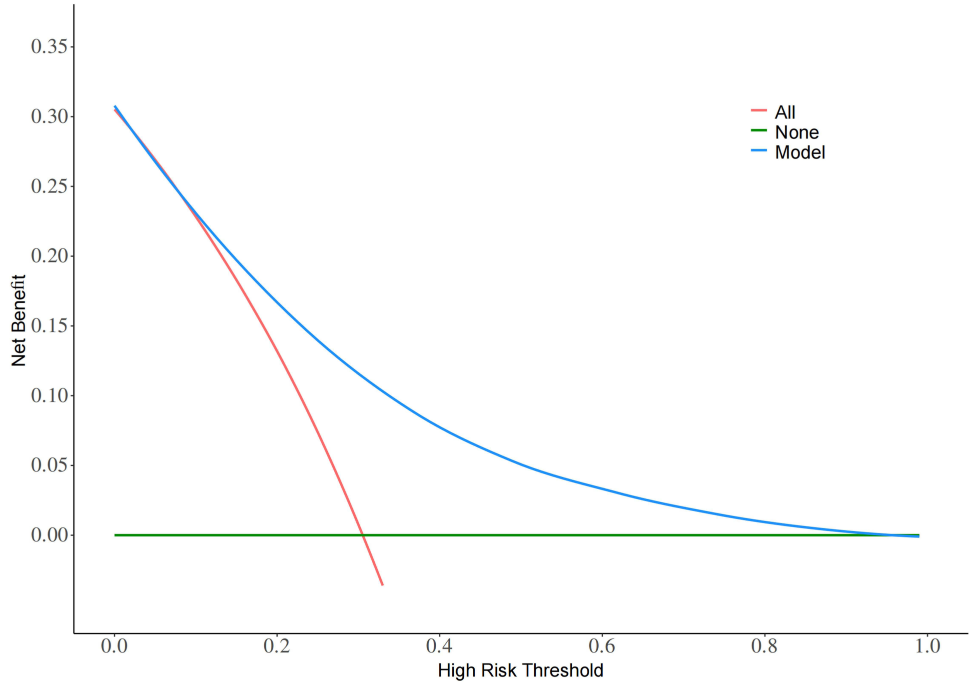

Figure 7 Training Set DCA Plot.

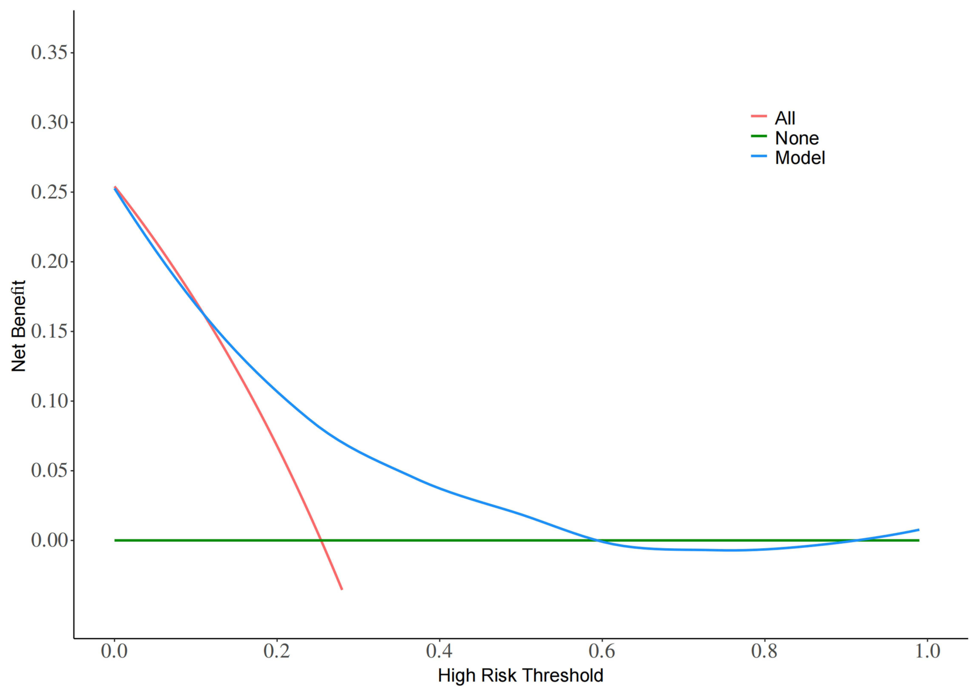

Figure 8 Validation Set DCA Plot.

prevention significantly exceeded that of both empirical full-intervention and full-nonintervention strategies. Similarly, within the threshold probability range of 0.1 to 0.6 on the validation set, the net benefit of model-guided PONV prevention notably surpassed both empirical full-intervention and full-nonintervention approaches.

Discussion

This study successfully developed and validated a prediction model specifically designed to assess the risk of postoperative nausea and vomiting (PONV) in patients undergoing thyroid cancer surgery. The model incorporates four readily available clinical variables and exhibits excellent discriminatory ability across both training and validation datasets, offering a practical quantitative tool for the precise prevention of PONV in this patient population.

Incidence of Postoperative Nausea and Vomiting in Thyroid Cancer Patients

The mechanisms underlying PONV in patients with thyroid cancer remain unclear and warrant further investigation. Current research suggests that the occurrence of thyroid PONV may be attributed to several factors, including excessive neck extension during surgery, postoperative pain, cervical edema, psychological factors, side effects of anesthetic drugs, vagus nerve stimulation during surgery,[16,17] as well as increased intracranial pressure and cerebral ischemia during the procedure.[18] In addition, anesthetic technique, anesthetic agents, and anesthesia duration are well-established risk factors for PONV. The incidence of PONV is significantly higher in patients undergoing general anesthesia than in those receiving neuraxial anesthesia, and is lower in patients undergoing total intravenous anesthesia (TIVA) than in those administered inhalational anesthesia. Patients exposed to volatile anesthetics have a 1.82-fold higher risk of PONV compared with those receiving other anesthetic agents. Inhalation of nitrous oxide (N_2O) for more than 1 hour is associated with a 20% increase in the risk of PONV. For each 1-hour prolongation of anesthesia duration, the odds of PONV occurrence increase by approximately 1.46-fold.[19] The overall incidence of PONV among thyroid cancer patients at our center was 29.01% (25.42% in the training set and 30.55% in the validation set), which is lower than most previously reported values in the literature. For instance, the Chinese Thyroid Association expert consensus indicates that the incidence of postoperative PONV in differentiated thyroid cancer can reach 60–76%,[20] and may even rise to 80% in the absence of prophylactic medication.[21] Zhang et al[14] reported an incidence rate of 68.9%. The relatively low incidence rate observed in this study may be attributed to the high prevalence of prophylactic intraoperative use of 5-HT3 receptor antagonists (such as ondansetron), which reached nearly 70%. This discrepancy highlights the effectiveness of routine preventive measures and indicates that identifying genuinely high-risk populations that require enhanced interventions is of greater clinical significance within the context of universal prevention.

Risk Factors for Postoperative Nausea and Vomiting in Thyroid Cancer Patients

The results of this study indicate that thyroid cancer patients aged ≥50 years have a higher probability of developing PONV, which is inconsistent with most previous studies. This discrepancy may be attributed to the presence of comorbidities in a portion of patients aged ≥50 years in this study, including hypertension, cervical spondylosis, diabetes, and heart disease, which collectively accounted for 43.55% of the cohort. In 2020, the International Society for the Study of Drug Effects (ISDDE) released the fourth edition of its Consensus Guidelines for the Management of PONV,[22] which incorporated younger patients (<50 years old) into the baseline risk factors for PONV occurrence. The guidelines emphasized the necessity for tailored prevention and management strategies based on individual patient circumstances; however, they did not include detailed exclusion criteria or analyses specifically addressing patients with comorbidities. Conversely, Koivuranta et al[23] suggest that age is not a primary factor influencing the incidence of PONV; rather, the risk of increased PONV incidence appears to emerge only in patients aged 50 years and older. Of the patients aged ≥50 years enrolled in this study, 50 (27.03%) had comorbid hypertension or heart disease, among whom 21 patients (42%) developed PONV. The studies indicate that patients with concomitant hypertension or heart disease may experience cerebral ischemia during surgery due to the burden of cardiovascular and cerebrovascular impairments, which can stimulate the nausea and vomiting centers.[16] Cervical spondylosis, the most common degenerative disorder of the cervical spine, affects the majority of individuals over 50 years of age. The cervical spine's unique role in facilitating extensive movement and protecting neural and vascular structures increases its susceptibility to degeneration.[24] In this study, 17 (9.19%) of patients aged ≥50 years had comorbid cervical spondylosis, among whom 6 (35.29%) developed PONV. We hypothesize that this finding may be attributed to irritation or compression of the cervical sympathetic ganglia and sympathetic plexus by cervical spondylosis-related pathological changes. Additionally, the neck hyperextension position and surgical stimulation during thyroid surgery may directly irritate the sympathetic nerves on the vertebral artery wall, causing vertebral artery spasm. This may result in symptoms such as dizziness, headache, nausea, and vomiting.[25]

This study aligns with the findings of Apfel et al, who found that a history of PONV or motion sickness significantly increases the risk of PONV. In 2012, Apfel et al conducted a systematic review and meta-analysis involving 22 prospective studies (n = 95,145) on PONV,[26] confirming previously identified risk factors:[27,28] female gender, a history of PONV or motion sickness, non-smoking status, and postoperative opioid use. Patients with a history of PONV or motion sickness exhibit a 1.8 to 3.1 times higher incidence of PONV compared to those without such a history.[29,30] These patients may possess pre-existing nausea-vomiting reflex circuits, which heighten their susceptibility to these symptoms. Additionally, studies suggest that motion sickness and nausea/vomiting may share identical or similar genetic phenotypes, further enhancing their interrelatedness.[31]

5-HT3 receptor antagonists are currently the most widely utilized medications for the prevention and treatment of PONV. Their proposed mechanism involves binding to 5-HT3 receptors, which act on peripheral gastrointestinal vagal afferents and the central parabrachial nucleus.[32] The most commonly used agent is ondansetron, for which the administration of 4 mg before the conclusion of surgery has been recommended as the "gold standard" for PONV prevention.[22] However, PONV symptoms are frequently missed, particularly nausea. One observational study has reported that only 42% of PONV episodes were recognized in the PACU, with 29% recognized in surgical units.[33] It has been shown that even with intensive training and education, the tendency to continue with de facto standard practice continues, and the adherence to risk-adapted PONV management protocol remains poor (between 35% and 50% compliance).[34,35] This indicates that identifying and addressing resistance to change is key to effectively implementing guidelines. Furthermore, the busy clinical environment may also make it difficult to achieve the ideal level of adherence to preventive medication. The research conclusions point out: "The compliance with PONV prevention guidelines is still at an extremely low level",[36] with less than half of medium to high-risk patients receiving the appropriate prophylaxis.[37] This study revealed that a deficiency in ondansetron prophylaxis was the strongest predictor of PONV, contributing 42% to the weight of the line chart, consistent with previous research findings.

Traditional views suggest that the first postoperative meal should be administered only after the patient passes gas for the first time,[38] as early postoperative feeding has been associated with an increased incidence of PONV. However, this traditional perspective is now being challenged by early oral feeding strategies grounded in the principles of enhanced recovery after surgery (ERAS). Multiple studies indicate that early postoperative feeding is safe, alleviates postoperative thirst and hunger, accelerates the recovery of gastrointestinal function, and reduces postoperative discomfort.[39,40] An ERAS study in gynecologic oncology demonstrated that early postoperative oral intake of fluids and food reduces abdominal distension and PONV, while also promoting gastrointestinal recovery.[41] The 2025 edition of the Chinese Cancer Association (CACA) Integrated Diagnosis and Treatment Guidelines for Thyroid Cancer states that patients may consume small amounts of water after regaining full consciousness following thyroid surgery. If no specific discomfort arises, they may gradually transition to a regular diet.[6] This study aligns with these findings, as early oral intake facilitates improved gastrointestinal recovery and enables earlier tolerance of food. The time to first oral intake (>6 hours)[42] after surgery has been identified as an independent predictive factor, with delayed oral intake significantly increasing risk, thereby supporting the ERAS practice of early restoration of oral intake following thyroid surgery.[43,44] However, early postoperative oral intake faces notable barriers in clinical practice. As shown in a Chinese multicenter survey,[42] although patients were instructed by ward nurses to start oral intake at 6 hours postoperatively, they remained cautious about early oral intake, with actual postoperative fasting longer than clinically recommended. The reasons for the guideline-practice gap and patients' conservative attitudes warrant further investigation in future studies.

Risk Prediction Model for Postoperative Nausea and Vomiting in Thyroid Cancer Patients

The development of a predictive model for PONV risk in thyroid cancer patients seeks to transition from empirical prevention to precision prevention and control. By integrating patient-specific characteristics with surgery-specific indicators, this model effectively identifies high-risk individuals, guides tiered prevention strategies, and enhances the efficient utilization of medical resources. Furthermore, it addresses the limitations of universal scoring systems in thyroid surgery, providing clinicians with a quantitative decision-making tool that significantly improves postoperative recovery. The model demonstrated good discriminatory ability in the training cohort, achieving an area under the curve (AUC) of 0.76. In the validation cohort, the AUC was 0.68, indicating that the model has some generalizability and potential clinical utility. Although the Apfel score is widely recognized as a system for assessing PONV risk, its predictive capability may be limited due to the restricted range of risk factors considered. In specialized surgeries, such as thyroid procedures involving unique anatomical locations, the incidence of nausea and vomiting is higher than in other postoperative settings, which may restrict the predictive performance of the Apfel score.[19] Zhang et al[14] demonstrated that the mFI outperformed the Apfel scoring system in predicting PONV accuracy among thyroid cancer patients. This discrepancy may arise from the high homogeneity of key risk factors—such as female gender, non-smokers, and the absence of postoperative opioid use—within the thyroid surgery cohort. Consequently, the Apfel score proves suboptimalin this surgical setting, highlighting the limitations inherent to any brief predictive risk-scoring system. Although the model's calibration curve indicates a slight overestimation of moderate-to-high risk, the decision-cost analysis confirms that the model's overall decision-making value remains unaffected. Combined with its high discriminatory power, positive predictive value (PPV), and decision flexibility, it accurately identifies patients requiring enhanced intervention. This approach effectively avoids overtreatment while ensuring that high-risk patients receive adequate protection.

Regarding model performance, we observed a reduction in discrimination (AUC) in the validation set (AUC = 0.68) compared with the training set (AUC = 0.76). This reduction suggests a degree of overfitting in the model, leading to impaired generalizability to previously unseen data. Such overfitting is not uncommon in predictive modeling studies that employ split-sample validation with single-center data, particularly when the validation set is small. A small validation subset may yield unstable performance estimates, and model complexity relative to the number of outcome events can further exacerbate this issue. Therefore, although the model demonstrated acceptable internal validity, its generalizability to external populations remains uncertain.

In this study, the calibration curve demonstrated good overall agreement between model-predicted and observed PONV probabilities, supported by the Hosmer-Lemeshow goodness-of-fit test ($P > 0.05$). However, we noted a slight overestimation of PONV risk in moderate-to-high risk patients in the validation set. Although this deviation did not reach statistical significance in the HL test, this graphical deviation warrants attention from a clinical prediction perspective. This may be explained by two factors: first, the limited sample size of the validation set and the low number of PONV events in moderate-to-high risk groups led to less robust calibration estimates in this risk interval; second, selection bias in single-center data may cause distorted predictions for specific risk subgroups. Thus, despite acceptable overall calibration, the model's predictions for moderate-to-high risk individuals should be interpreted with caution.

To evaluate the clinical applicability of the proposed model, we performed Decision Curve Analysis (DCA). The results showed that the model conferred a positive net benefit across a range of threshold probabilities in both the training and validation sets, indicating its potential to support clinical decision-making in PONV prophylaxis. Of note, the benefit range (threshold probability: 0.1–0.6) in the validation set was narrower than that in the training set. In the context of PONV prevention, the threshold probability is the minimum risk at which clinicians or patients would consider initiating antiemetic prophylaxis. A threshold below 0.1 corresponds to a "treat-almost-all" strategy, where clinical uncertainty is low, and the incremental value of the predictive model is limited; a threshold above 0.6 reflects a highly conservative strategy, with intervention restricted to only patients at extremely high risk. Therefore, the range of 0.1 to 0.6 precisely captures the critical decision-making interval with clinical equipoise, the scenario in which the model delivers the greatest value for decision support. The attenuation of net benefit outside this range in the validation set may be partially due to the limited sample size of high-risk patients in the validation cohort, resulting in insufficient statistical power at higher thresholds. Importantly, the model retains clinical utility for typical scenarios with genuine clinical uncertainty.

Limitations

This study presents several limitations that must be carefully considered when interpreting the results and contemplating clinical implementation. First, the data were derived from medical records, a method that may not fully capture all potential predictive variables (such as detailed patient anxiety scores or precise surgical procedures) and is susceptible to inherent selection and information biases. Second, the development and validation of this model were conducted using a single-center dataset through "split validation". While this approach allows a preliminary assessment of model performance, the relatively small sample size of the split validation set may yield unstable estimates of performance metrics, such as discriminative power and calibration. Furthermore, it may overestimate the model's generalization ability in unseen populations. The model's universality still requires confirmation in more diverse external cohorts. Finally, the data for this study originated from a single institution, whose patient population characteristics, surgical procedures, and perioperative management protocols exhibit a high degree of homogeneity. Consequently, the applicability of this model to other healthcare institutions, different healthcare systems, or diverse geographic populations remains uncertain. Before widespread implementation of this model in clinical practice, its efficacy and robustness must be definitively confirmed through prospective, multicenter external validation studies.

Conclusion

This study developed and validated a specialized risk prediction model for PONV in patients with thyroid cancer. Utilizing four clinically relevant variables, the model exhibited excellent predictive performance. It serves as an effective tool for personalized, precision-based PONV prevention, with the potential to optimize clinical decision-making and enhance patients' postoperative recovery experiences. The clinical utility of this model necessitates further confirmation through prospective studies.

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Disclosure

The authors declare that they have no competing interests in this work.

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