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# Factors contributing to perioperative blood transfusion during total hip arthroplasty in patients continuing preoperative aspirin treatment: a nomogram prediction model

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## Abstract

**Background** Total hip arthroplasty (THA) is associated with considerable blood loss during the perioperative period, which commonly requires a blood transfusion, especially in patients who continue aspirin treatment preoperatively. Blood transfusion can significantly increase both the length of hospital stay and total treatment costs and is potentially associated with adverse reactions. However, a visual predictive model for assessing the risk of blood transfusion in THA patients is lacking. The aim of this study was to develop and validate a nomogram to predict the risk of blood transfusion during THA in patients who continue aspirin treatment preoperatively.

**Methods** From June 2016 to December 2022, 228 consecutive patients who continued preoperative aspirin treatment and underwent primary unilateral THA were enrolled in this retrospective study. Potential risk factors were screened using least absolute shrinkage and selection operator (LASSO) regression, and univariate and multifactorial logistic regressions were performed on the factors screened using LASSO regression to further control for confounding effects. Finally, a nomogram was constructed on the basis of the variables identified through multiple regression analysis. Internal validation was carried out using the Bootstrap method to assess the performance of the model using the C-index, area under the receiver operating characteristic curve (AUC), calibration curve, and decision curve analysis (DCA).

**Results** Among the 228 patients, 43 (18.9%) received a blood transfusion. Patients who received a blood transfusion had a longer hospital stay ($p = 0.01$). The independent risk factors for blood transfusion included the concomitant use of clopidogrel (OR = 4.415), preoperative hemoglobin level (OR = 0.062), total estimated blood loss volume

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(OR = 3.411), American Society of Anesthesiologists (ASA) class (OR = 1.274), and the use of tranexamic acid (OR = 0.348). The prediction model had a C-index of 0.862, an internally validated C-index of 0.833, and an AUC of 0.833, indicating excellent discriminatory power. The calibration curve showed a good calibration effect, and DCA indicated that the nomogram has strong clinical applicability.

**Conclusions** Based on these five independent risk factors, our nomogram can accurately predict the risk of blood transfusion in THA patients who continue aspirin treatment preoperatively, thereby assisting surgeons in clinical decision-making.

**Keywords** Total hip arthroplasty, Blood transfusion, Risk factors, Nomogram, Continuation of aspirin

## Introduction

Total hip arthroplasty (THA) is commonly associated with considerable blood loss. As a standard treatment for blood loss following THA, the transfusion of blood products carries inherent risks, including delayed discharge, increased overall hospitalization costs, high risks of associated comorbidities, and increased mortality rates [1–3]. The prevalence of blood transfusion during THA is estimated to reach 26%, with an average rate of approximately 18% [1, 4, 5]. In patients undergoing THA, the preoperative continuation of aspirin can reduce the risk of cardiovascular or cerebrovascular events [6]. However, considering the potential bleeding risk associated with antiplatelet agents, surgical techniques and blood management strategies have been developed to minimize blood loss in patients who continue aspirin treatment prior to THA and reduce the need for blood transfusion [7].

To date, many risk factors for predicting blood transfusion during THA have been explored, including advanced age, female sex, longer operation times, lower preoperative hemoglobin (Hb) levels and higher American Society of Anesthesiologists (ASA) classes [1, 7–9]. However, the associations of these factors with outcomes have not been consistently reported in the literature, leading to uncertainty regarding the accuracy of outcome predictions. Nomograms are reliable predictive tools that are widely used in various medical disciplines for complex statistical analyses. These tools allow clinicians to estimate the probability of an event by assigning a specific score to each variable, which is then used to predict the probability, typically presented in a visual format [10, 11].

Previously, several studies have used nomograms to investigate the risk factors for blood transfusion during THA in both fracture and nonfracture patients [12, 13]. However, few studies have focused on visual models that can intuitively predict the risk of blood transfusion in THA patients who continue to use aspirin preoperatively. Given that aspirin is commonly used for the prevention of cardiovascular or cerebrovascular disease in adults aged 60 years and older, and based on our previous study [7], the purpose of this study is to develop and validate a reliable nomogram to predict the risk factors for blood transfusion in THA patients who continue aspirin treatment preoperatively. This tool aims to assist surgeons in improving patient selection, individualizing surgical procedures, and ultimately enhancing clinical outcomes following THA.

## Materials and methods

### Patient selection

From June 2016 to December 2022, a total of 252 consecutive patients who used continuous low-dose (100 mg/d) aspirin (Bayer Pharma AG, Berlin, Germany) and underwent primary unilateral THA at our hospital were eligible for our retrospective study. The inclusion criteria were: patients aged ≥ 18 years, undergoing THA due to femoral neck fracture, osteonecrosis of the femoral head, hip dysplasia, or osteoarthritis. The exclusion criteria included: (1) patients with multiple injuries or pathological fractures; (2) reported aspirin use for less than six months; (3) thromboembolic and major bleeding events within six months prior to THA; (4) evidence of fibrinogen or fibrinolysis disorders; and (5) incomplete data.

Among the 252 patients, nine patients were excluded due to aspirin use for less than six months, and 15 patients were excluded due to incomplete data. Thus, 228 patients were included in the final cohort. The ethics committee of our hospital approved the study (YJ2022034), and the need for informed consent was waived by the board, as this was a retrospective study and all data were collected and analyzed anonymously with no potential harm to the patients.

### Data collection

All patients underwent cementless THA via a posterolateral approach performed by two senior surgeons. For patients receiving dual antiplatelet therapy, THA was performed more than 5 days after discontinuing clopidogrel. All patients continued aspirin therapy postoperatively to prevent deep vein thrombosis (DVT) and did not receive direct oral anticoagulants (DOACs) or other anticoagulants.

The patients were divided into two groups according to blood transfusion status: the non-blood transfusion group and the blood transfusion group. The indications

for blood transfusion included a postoperative Hb level < 80 g/L or < 100 g/L with symptoms of anemia.

The general characteristics documented included age, sex, body mass index (BMI), primary disease, history of cardiovascular or cerebrovascular events, and concomitant use of clopidogrel. Hematological variables, including preoperative Hb, activated partial thromboplastin time (APTT), and platelet count (PLT), were collected. Other variables documented include ASA class, total blood loss volume, operative time, length of hospital stay, and the use of tranexamic acid (TXA). The total estimated blood loss (EBL) was calculated based on the decrease in hematocrit (Hct) between the preoperative value and the lowest Hct during hospitalization, using the Gross formula and Nadler's algorithm [14, 15]. Operative time was defined as the during from skin incision to skin closure, as recorded in the anesthesia record sheet. Length of hospital stay was extracted from the medical records system and presented as the number of nights hospitalized after the procedure. The venous and topical use of TXA was standardized according to our previous study [7]. Finally, thromboembolic and bleeding events within 90 days after THA, as well as other postoperative complications, were recorded.

### Statistical analysis

Data processing and statistical analysis were performed using SPSS 25.0 (Statistical Product and Service Solutions, IBM) and R software (version 4.1.2). The normality of the data was assessed using the Shapiro-Wilk test. Categorical data are presented as numbers (percentages), and continuous data are expressed as means and standard deviations or as medians and interquartile ranges, as appropriate. Student's *t*-test was used to compare the differences between two groups for normally distributed continuous variables, while the Mann–Whitney U-test was applied for nonparametric variables. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate.

To delve deeper into the potential relationship between variables and blood transfusion, continuous variables were discretized into categorical variables based on either commonly used classification thresholds in clinical practice or those provided in the relevant literature. Potential risk factors were identified using the least absolute shrinkage and selection operator (LASSO) regression method [16, 17]. Univariate and multifactorial logistic regression analyses were subsequently performed on the factors identified by LASSO regression to further control for confounding effects. The selected variables were incorporated into the generated nomogram via multiple regression analysis.

The model's performance was assessed using various metrics, including the C-index, area under the receiver operating characteristic curve (AUC), calibration curve, and decision curve analysis (DCA). To ensure the accuracy and reliability of the model, internal validation was performed using repeated sampling (1000 replicates) to calculate the corrected C-index [18]. Calibration was evaluated by comparing the predicted probability curves with the actual probability curves, with closer alignment indicating better calibration [19]. Finally, the clinical utility of the nomogram was evaluated by quantifying the net benefit across various threshold probabilities using decision curve analysis [20, 21]. A $p$ value < 0.05 was considered statistically significant.

## Results

Among the 228 patients, 74 patients (32.5%) were male, and 154 (67.5%) were female, with a mean age of 69.3 ± 8.6 years. Among them, 43 patients (18.9%) who received a blood transfusion were included in the blood transfusion group, and the remaining 185 patients were included in the non-blood transfusion group. The mean follow-up duration was 51.2 ± 20.7 months. The baseline characteristics and clinical data are summarized in Table 1. No significant differences were observed between the two groups in terms of age, sex, BMI, primary disease, history of cardiovascular or cerebrovascular events, APTT, or PLT count. However, patients receiving a combination of clopidogrel and aspirin had a significantly higher transfusion rate compared to those receiving aspirin alone (38.9% versus 15.1%, $p = 0.001$).

The blood transfusion group had significantly longer operative times ($p = 0.001$), lower preoperative Hb levels ($p < 0.001$) and higher total EBL volumes ($p < 0.001$) compared to the non-blood transfusion group. Additionally, the transfusion rate in patients with ASA III and IV classifications was significantly higher than in those classified as ASA I and II (48.6% vs. 4.5%, $p < 0.001$). Patients who did not receive TXA also had a significantly higher transfusion rate compared to those who did (26.6% vs. 9.6%, $p = 0.001$). Consequently, patients in the blood transfusion group had a longer hospital length of stay (LOS) ($p = 0.01$).

LASSO regression was performed in R software to reduce the initial set of 13 factors to 8 potential predictors (Fig. 1), all of which presented nonzero coefficients in the LASSO regression model. These factors included the concomitant use of clopidogrel, preoperative Hb level, preoperative PLT count, total EBL volume, operation time, ASA class and TXA use. These seven factors were subjected to univariate analysis (Table 2), followed by subsequent multivariate logistic regression analysis. Ultimately, five factors- concomitant use of clopidogrel, preoperative Hb level, ASA class, total EBL volume, and TXA use, were identified as independent risk factors associated with blood transfusion in THA patients who

**Table 1** General characteristics and clinical data of the patients included in the study ($n = 228$)

| Variables | Non-blood transfusion group ($n = 185$) | Blood transfusion group ($n = 43$) | *p*-value |
|---|---|---|---|
| Age (year) | | | 0.885 |
| Mean (SD) [range] | 69.5 (8.8) [44–88] | 69.1 (7.9) [55–84] | |
| Sex, No. (%) | | | 0.153 |
| Female | 121 (65.4) | 33 (76.7) | |
| Male | 64 (34.6) | 10 (23.3) | |
| BMI ($kg/m^2$) | | | 0.485 |
| Mean (SD) [range] | 23.8 (3.7) [16.6–33.6] | 24.3 (4.0) [17.8–32.8] | |
| Disease, No. (%) | | | 0.614 |
| FNF | 72 (38.9) | 16 (37.2) | |
| ONFH | 54 (29.2) | 14 (32.6) | |
| DDH | 34 (18.4) | 10 (23.3) | |
| OA | 25 (13.5) | 3 (6.9) | |
| History, No. (%) | | | 0.349 |
| Hypertension | 88 (47.6) | 15 (34.9) | |
| Stroke | 45 (24.3) | 12 (27.9) | |
| Coronary atherosclerotic heart disease | 24 (13.0) | 6 (14.0) | |
| Atrial fibrillation | 16 (8.6) | 3 (6.9) | |
| Sequelae of myocardial infarction | 5 (2.7) | 3 (6.9) | |
| Carotid stenosis | 7 (3.8) | 4 (9.4) | |
| Concomitant use of clopidogrel, No. (%)* | | | 0.001 |
| Yes | 22 (11.9) | 14 (32.6) | |
| No | 163 (88.1) | 29 (67.4) | |
| Preoperative Hemoglobin (g/L)* | | | <0.001 |
| Mean (SD) [range] | 132 (12.6) [102–159] | 120 (9.6) [102–140] | |
| APTT (s) | | | 0.803 |
| Mean (SD) [range] | 34.5 (3.7) [27–49] | 34.3 (4.4) [28–51] | |
| Preoperative PLT ($\times 10^9/L$) | | | 0.775 |
| Mean (SD) [range] | 211 (53) [85–384] | 209 (44) [115–301] | |
| Total estimated blood loss (ml)* | | | <0.001 |
| Mean (SD) [range] | 990 (385) [243–2345] | 1255 (417) [505–2325] | |
| Operation time (min)* | | | 0.001 |
| Mean (SD) [range] | 76 (17.8) [45–144] | 88 (27.1) [56–180] | |
| Length of stay (day)* | | | 0.01 |
| Mean (SD) [range] | 6.2 (3.5) [2–18] | 7.6 (2.9) [4–18] | |
| ASA class, No. (%)* | | | 0.009 |
| I/II | 147 (79.5) | 7 (16.3) | |
| III/IV | 38 (20.5) | 36 (82.7) | |
| Use of TXA, No. (%)* | | | 0.001 |
| Yes | 94 (50.8) | 10 (23.3) | |
| No | 91 (49.2) | 33 (76.7) | |

SD: standard deviation; BMI: body mass index, FNF: femoral neck fracture; ONFH: osteonecrosis of the femoral head; DDH: developmental dysplasia of the hip; OA: osteoarthritis; APTT: activated partial thromboplastin time; PLT: platelet; ASA: American Society of Anesthesiologists; TXA: tranexamic acid

* Statistically significant difference of data ($p < 0.05$)

continued aspirin preoperatively (Table 3). These factors were subsequently incorporated into the predictive model, and a nomogram was developed to visualize the logistic regression analysis results (Fig. 2). This approach enables clinicians to perform a personalized assessment of transfusion risk in THA patients. For an individual patient, the score for each factor in the nomogram is determined by drawing a vertical line from each factor to the "points" axis. These scores are then summed to calculate a total score. Finally, a vertical line is drawn from the "Total Score" axis to intersect with the "Transfusion Risk" axis on the basis of the total score, providing the patient's corresponding probability of transfusion. This method facilitates the identification of high-risk individuals for transfusion and improves communication between healthcare doctors and patients.

The model demonstrated a C-index of 0.862 (95% CI: 0.804–0.920), with an internally validated C-index of

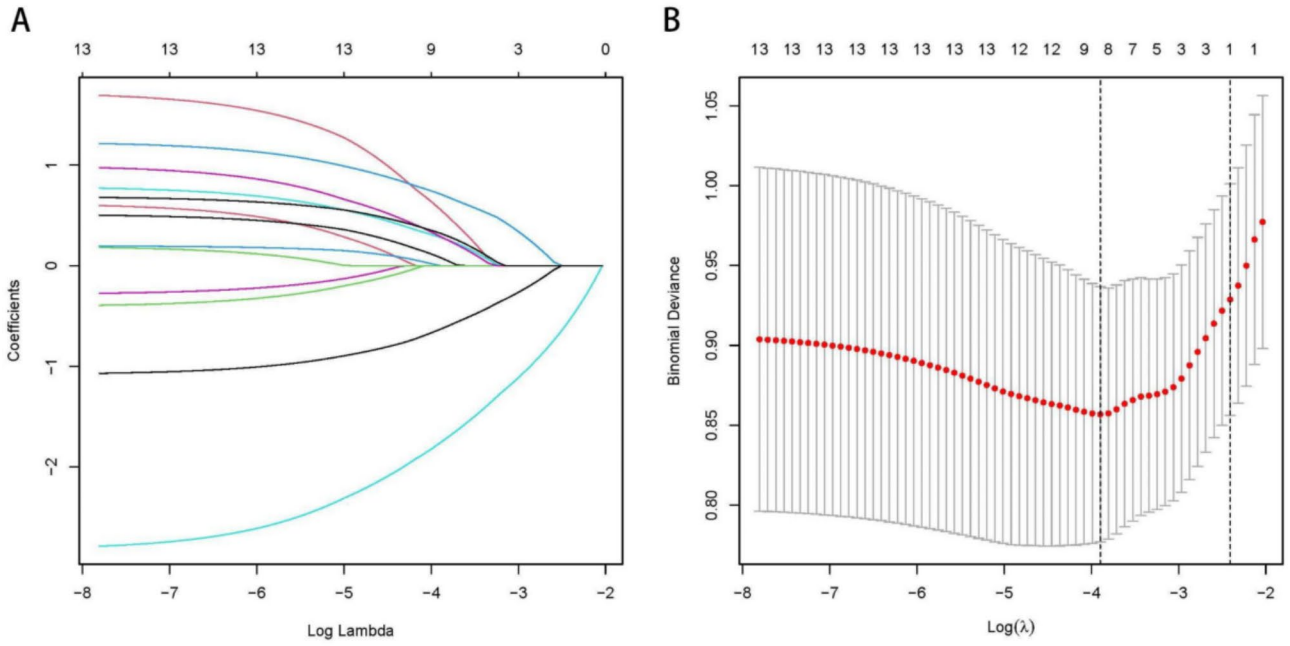


**Fig. 1** Least absolute shrinkage and selection operator (LASSO). (**A**) LASSO coefficient profiles. (**B**) Ten-time cross-validation for tuning parameter selection in the LASSO model. The red dots represent the binomial deviance for different values of log(λ), the vertical bars represent the standard error. LASSO regression showed that 8 variables were selected for further logistic regression analysis when the error of model is minimized

**Table 2** Results of univariate logistic analysis to predict blood transfusion

| | OR | 95% CI | *p*-value |
|---|---|---|---|
| Concomitant use of clopidogrel* | 1.745 | 1.250–2.433 | 0.001 |
| Preoperative Hemoglobin* | 0.136 | 0.057–0.321 | <0.001 |
| Preoperative PLT | 1.277 | 0.655–2.489 | 0.473 |
| Total EBL* | 2.775 | 1.361–5.657 | 0.005 |
| Operation time | 1.86 | 0.94–3.68 | 0.075 |
| ASA class | 0.668 | 0.314–1.422 | 0.295 |
| Use of TXA* | 0.293 | 0.137–0.63 | 0.002 |

OR: odds ratio; CI: confidence intervals; PLT: platelet; EBL: estimated blood loss; ASA: American Society of Anesthesiologists; TXA: tranexamic acid

* Difference of data statistically significant ($p < 0.05$)

**Table 3** Multivariate logistic analysis of risk factors for blood transfusion

| | Regression coefficient | OR | 95%CI | *p*-value |
|---|---|---|---|---|
| Concomitant use of clopidogrel* | -1.515 | 4.415 | 1.557–12.514 | 0.005 |
| Preoperative Hemoglobin* | -2.567 | 0.062 | 0.021–0.184 | <0.001 |
| Preoperative PLT | 0.766 | 1.58 | 0.676–3.694 | 0.291 |
| Total EBL* | 1.383 | 3.411 | 1.336–8.705 | 0.01 |
| Operation time | 0.129 | 2.118 | 0.856–5.239 | 0.104 |
| ASA class* | 1.274 | 4.076 | 1.358–12.233 | 0.012 |
| Use of TXA* | -0.920 | 0.348 | 0.134–0.904 | 0.03 |

OR: odds ratio; CI: confidence intervals; PLT: platelet; EBL: estimated blood loss; ASA: American Society of Anesthesiologists; TXA: tranexamic acid

* Difference of data statistically significant ($p < 0.05$)

0.833 for the predictive nomogram and an AUC of 0.833 on the receiver operating characteristic (ROC) curve (Fig. 3). These results highlight the excellent discriminatory power of the nomogram developed in this study. Additionally, the calibrated curves which evaluate the risk of blood transfusion in THA patients who continue aspirin preoperatively, demonstrated good agreement within this dataset. Overall, the nomogram exhibited strong performance in predicting the risk of blood transfusion (Fig. 4).

To evaluate the clinical feasibility of the prediction model, a DCA was performed. DCA is an innovative method to evaluate the net clinical benefit of a nomogram. The analysis indicated that both clinicians and patients would derive greater benefit from using the model to predict transfusion risk when the threshold probability falls between 1% and 86% (Fig. 5).

During the follow-up, the most common complication within postoperative 90 days was incisional ecchymosis (7.0%), followed by DVT (3.1%) and wound bleeding (2.6%) (Table 4). The overall complication rate was significantly higher in the blood transfusion group (13/43, 30.2%) compared to the non-blood transfusion group (27/185, 15.1%, $p = 0.015$). Among all the bleeding and thromboembolic events, only the incidence of incisional ecchymosis differed significantly between the two groups. In the blood transfusion group, one patient with a postoperative infection and another with an incisional hematoma were readmitted for reoperation, whereas in the non-blood transfusion group, two patients underwent

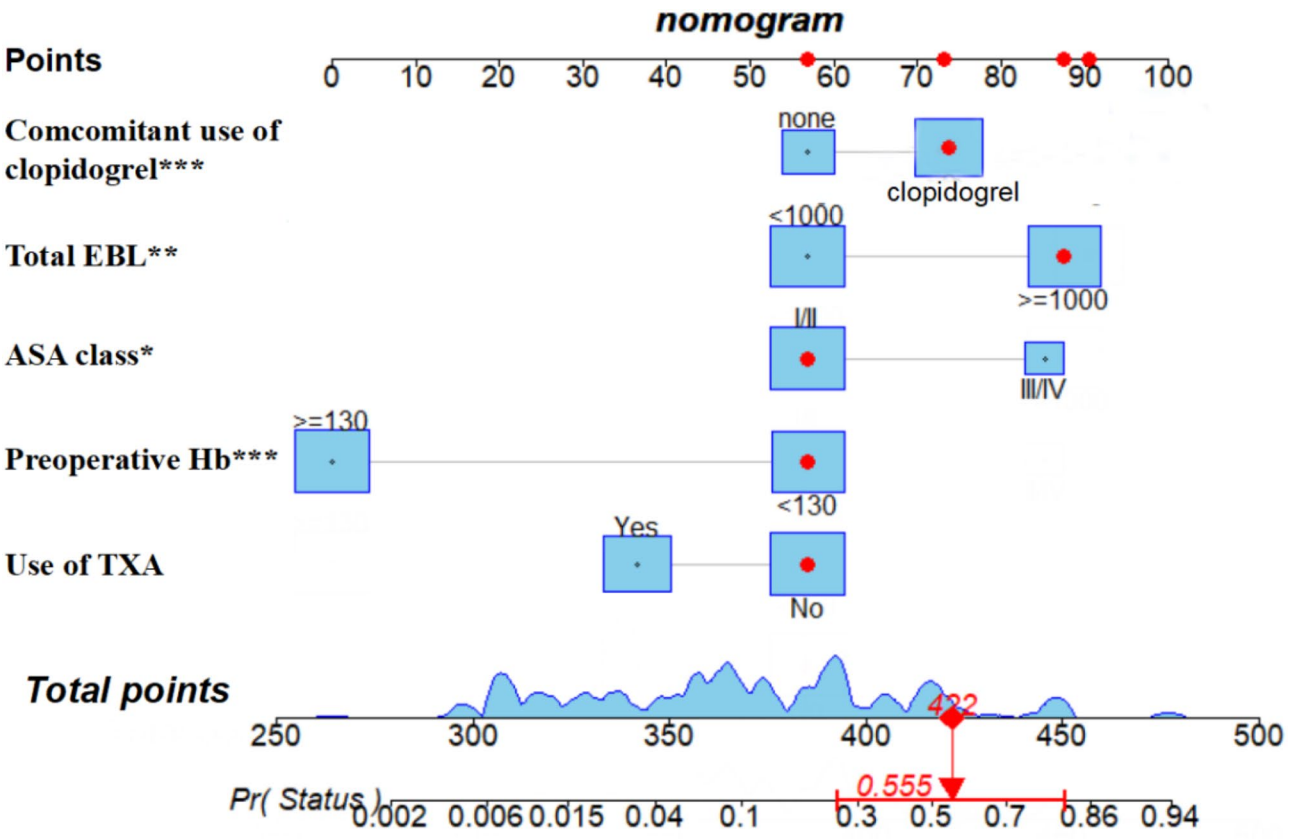


**Fig. 2** A nomogram based on the 5 independent predictors of blood transfusion during total hip arthroplasty in patients continuing treatment with aspirin preoperatively. The example case highlighted in red on the nomogram represents an actual randomized patient case. TXA: tranexamic acid; Hb: hemoglobin; ASA: American Society of Anesthesiologists; EBL: estimated blood loss. *$P < 0.05$;**$P < 0.01$:***$P < 0.001$

reoperation due to infection. Additionally, the readmission rate was significantly higher in the blood transfusion group (14.0%) than in the non-blood transfusion group (2.2%, $p = 0.001$).

## Discussion

Our study identified concomitant use of clopidogrel, preoperative Hb level, total EBL volume, ASA class and tranexamic acid use as independent risk factors for blood transfusion in THA patients who continued aspirin preoperatively. Based on these factors, we finally established and validated a nomogram that accurately predicts transfusion risk. A key strength of our study is that this nomogram model can be effectively applied to THA patients who continue aspirin preoperatively, as it was specifically designed for this population. Unlike previous models, our nomogram incorporates predictive variables that are easily obtained from routine preoperative assessments. Furthermore, the model demonstrated strong discriminative ability and calibration. Therefore, this predictive tool can assist surgeons in quickly evaluating transfusion risk in THA patients and serve as a valuable reference for clinical decision-making.

For decades, preoperative antiplatelet therapy has been associated with an increased risk of perioperative bleeding and intraoperative blood loss. Consequently, a widely accepted consensus recommends discontinuing antiplatelet medication at least seven days prior to major surgery. However, recent studies have provided strong evidence supporting the perioperative continuation of aspirin in orthopedic surgery patients [22–24]. In agreement with our previous study [7], the current study confirmed the safety and feasibility of continuing aspirin before surgery, as THA patients demonstrated a similarly low risk of major bleeding events.

In contrast, the perioperative use of clopidogrel in elective orthopedic procedures remains controversial [25–29]. Jacob et al. [26] reported that patients who continued clopidogrel preoperatively had a significantly higher risk of requiring a blood transfusion within 24 h of surgery and during hospitalization. Clinical consensuses suggest that discontinuing clopidogrel at least five days before total joint arthroplasty reduces the risk of bleeding events

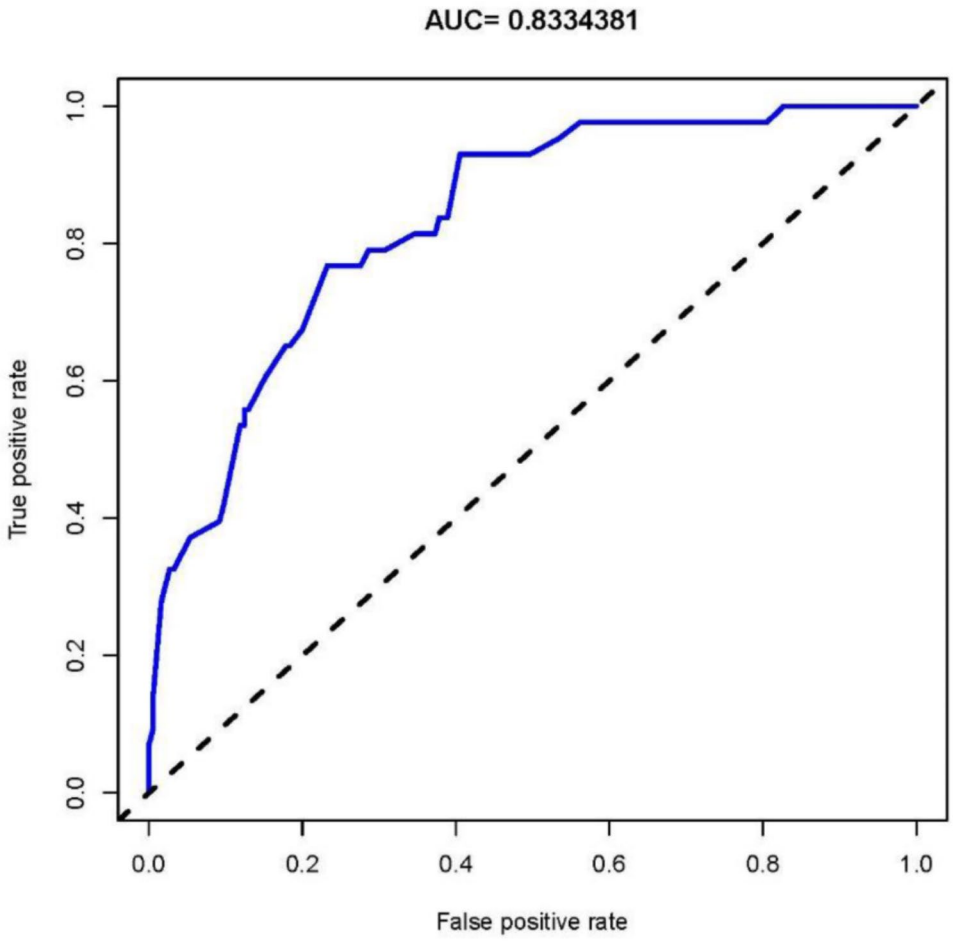


**Fig. 3** Receiver operating characteristic curve

[30, 31]. In our study, patients receiving both clopidogrel and aspirin had a relatively high transfusion rate (12/36, 39.9%). Given that concomitant clopidogrel use was identified as an independent risk factor for blood transfusion, we still strongly recommend discontinuing clopidogrel at least five days before THA, while continuing aspirin. However, since prolonged discontinuation of clopidogrel significantly increases the risk of cardiovascular and cerebrovascular events, the optimal timing for stopping clopidogrel before THA requires further investigation.

In our prediction model, preoperative Hb level had the greatest impact on the risk of blood transfusion, followed by total EBL and ASA class. In agreement with our findings, numerous clinical studies have identified preoperative Hb level as the most significant predictor of blood transfusion in total joint arthroplasty [32, 33]. So-Osman et al. [34] reported that patients with a preoperative Hb level above 130 g/L were ineligible for erythropoietin and evaluated the effect of autologous blood reinfusion. As a step toward exploring the definitive risk factors for blood transfusion, we finally employed 130 g/L as the threshold to highlight the significance of the prediction model.

The ASA classification is a simple yet effective tool used by anesthesiologists to categorize patients' overall preoperative health status based on underlying comorbidities. A study based on a national joint replacement registry database found that ASA class was correlated with 30-day and 90-day mortality, as well as postoperative complications and prolonged LOS, with an ASA class ≥ 3 was associated with a threefold increased risk of readmission [35]. To further investigate these associations, we categorized patients into ASA I/II and III/IV groups. Our findings corroborate previous studies on THA patients, confirming that ASA class is a significant predictor of postoperative transfusion risk [36–38]. Notably, over 80% of the patients who received blood transfusions in our study were classified as ASA III or higher. Given that a preoperative ASA class of III/IV was strongly associated with blood transfusion and corresponded to a 28-point increase in the transfusion risk score, it serves as a crucial factor in refining transfusion risk prediction when combined with other clinical variables.

Published studies have reported inconsistent findings regarding the overall transfusion rate in THA patients

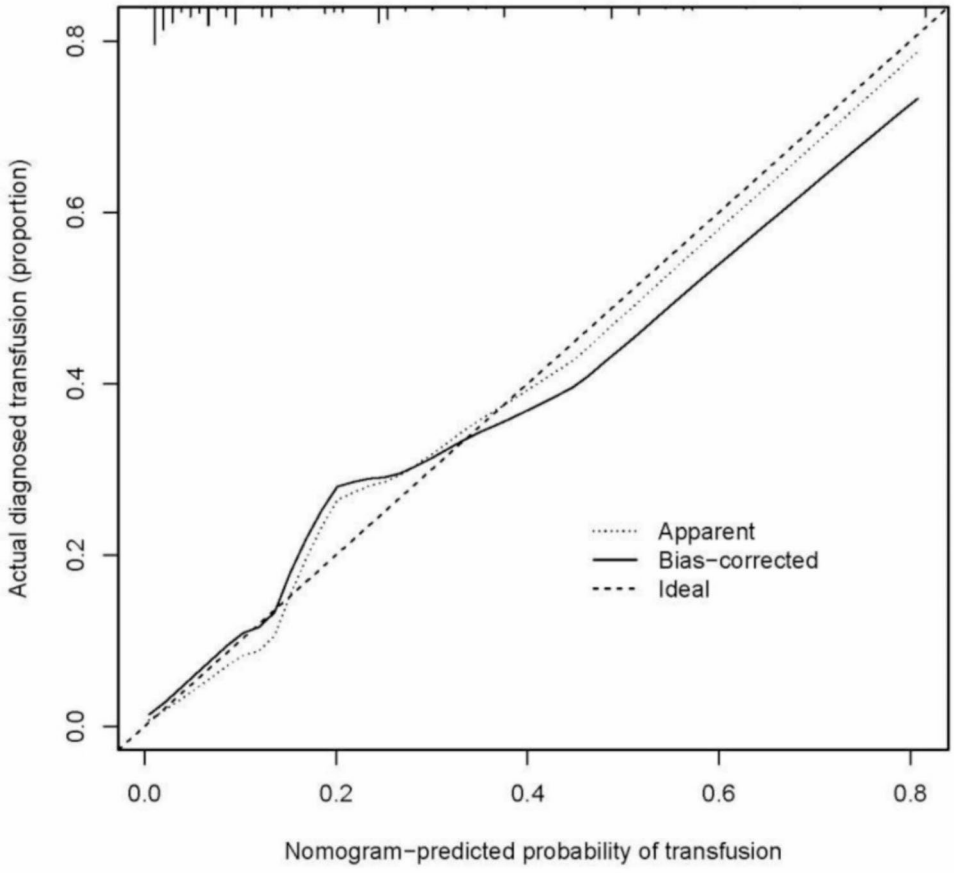


**Fig. 4** Calibration curve

who continue aspirin therapy. In our study, the transfusion rate was 18.9%, which was relatively higher than rates reported in other studies [39, 40]. These discrepancies can be attributed to variations in patient selection and blood management strategies. Many previous studies reported lower transfusion rates, likely due to the exclusion of patients receiving multiple antiplatelet agents. Although discontinuing clopidogrel at least five days before THA is considered safe and does not increase the risk of major bleeding complications, we still believe that its use, in combination with other factors, may contribute to a higher transfusion risk. Furthermore, the lack of routine TXA administration at the early stage of our study may have contributed to the relatively high transfusion rate. Notably, after implementing TXA as part of the standard treatment protocol, the transfusion rate dropped to below 10%. TXA administration has been shown to significantly reduce total EBL volume during THA without increasing the risk of thromboembolic events [7, 41]. According to our prediction model, patients with a total EBL volume exceeds 1000 mL have a 31-point increase in their transfusion risk score. Therefore, identifying at-risk populations based on these predictive factors can help to optimize blood management strategies, ultimately reducing transfusion risk and improving postoperative recovery after THA.

There are several limitations in this study. First, as a retrospective, single-center study, selection bias is inevitable, and the findings may not be generalizable across diverse populations or healthcare settings. Multicenter large-sample prospective studies are needed in the future to minimize this bias and further validate the nomogram. Second, although we identified key transfusion-related risk factors, certain potential predictors, such as hematocrit, international normalized ratio (INR), and the duration of aspirin use, were not included, which may limit the comprehensiveness of the analysis. Additionally, data on other antiplatelet regimens and comorbid conditions affecting hemostasis could have provided further insight. Third, differences in blood management strategies and transfusion policies across hospitals may hinder the broader adoption of this nomogram, potentially affecting its clinical applicability. Furthermore, certain high-risk subgroups, such as patients on dual antiplatelet therapy, had limited representation in our cohort, which may impact the statistical reliability of the findings. Finally, while the model demonstrated robust performance based on the internal C-index and calibration curves, its

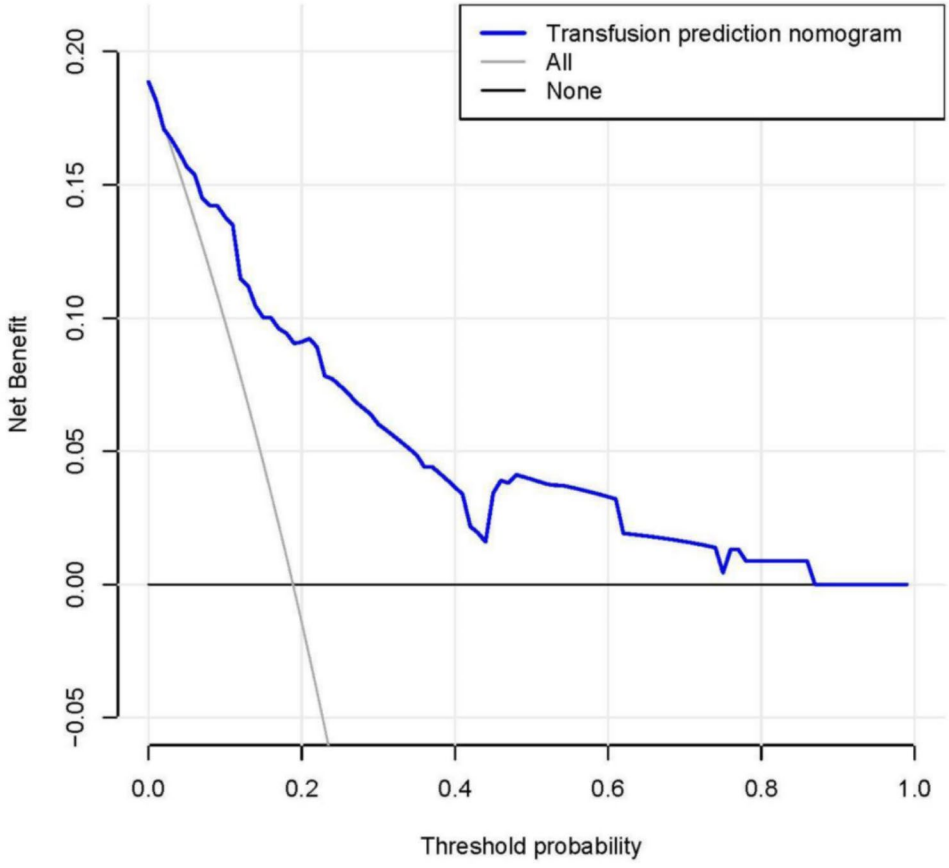


**Fig. 5** Decision curve analysis

**Table 4** Ninety-day postoperative complications in the two groups ($n = 228$)

| Complications | Non-blood transfusion group ($n = 185$) | Blood transfusion group ($n = 43$) | *p*-value |
|---|---|---|---|
| Bleeding events, No.(%) | | | |
| Incisional ecchymosis* | 9 (4.9%) | 7 (16.3%) | 0.008 |
| Wound bleeding | 4 (2.2%) | 2 (4.7%) | 0.316 |
| Incisional hematoma | 3 (1.6%) | 2 (4.7%) | 0.238 |
| Gastrointestinal bleeding | 1 (0.5%) | 1 (2.3%) | 0.342 |
| Thromboembolic events, No.(%) | | | |
| DVT | 5 (2.7%) | 2 (4.7%) | 0.505 |
| PE | 0 | 0 | |
| Other complications, No.(%) | | | |
| Dislocation | 3 (1.6%) | 0 | 0.533 |
| Infection | 2 (1.1%) | 1 (2.3%) | 0.467 |
| Re-operation | 2 (1.1%) | 2 (4.7%) | 0.162 |
| Readmission* | 4 (2.2%) | 6 (14.0%) | 0.001 |

DVT: deep vein thrombosis; PE: pulmonary embolism

* Statistically significant difference of data ($p < 0.05$)

predictive accuracy requires external validation. Moreover, real-world implementation challenges, such as clinician usability and patient variability, were not extensively explored, warranting further investigation to enhance the model's practical application in diverse clinical settings.

## Conclusions

To summarize, our nomogram, based on risk factors—including concomitant use of clopidogrel, preoperative Hb level, total EBL volume, ASA class, and TXA use, can accurately predict the risk of blood transfusion in THA patients who continue aspirin preoperatively. This tool can assist surgeons in clinical decision-making by enabling individualized risk assessment and optimizing perioperative management.

### Author contributions

All authors had full access to the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Q.Z. and L.Z. Acquisition of data: W.C.C, M.C. and R.L.H. Analysis and interpretation of the data: D.L.H, Q.Z and M.Y. Drafting of the manuscript: D.L.H. and Q.Z. Critical revision of the manuscript for important intellectual content: M.Y and L.Z. Statistical analysis: F.H.W. and M.Y. Obtained funding: W.C.C and R.L.H. Study supervision: L.Z.

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**Data availability**
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request; please contact the corresponding author, Dr. Wu.

## Declarations

**Ethics approval and consent to participate**
This retrospective study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Institutional Review Board of Rui'an People's Hospital approved this study (IRB: YJ2022034). Informed consent was obtained from all participants.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare no competing interests.

**Clinical trial number**
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