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Research Article

Prediction and Evaluation of Machine Learning Algorithm for Prediction of Blood Transfusion during Cesarean Section and Analysis of Risk Factors of Hypothermia during Anesthesia Recovery

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Objective. To explore the application of machine learning algorithm in the prediction and evaluation of cesarean section, predicting the amount of blood transfusion during cesarean section and to analyze the risk factors of hypothermia during anesthesia recovery. *Methods*. (1)Through the hospital electronic medical record of medical system, a total of 600 parturients who underwent cesarean section in our hospital from June 2019 to December 2020 were included. The maternal age, admission time, diagnosis, and other case data were recorded. The routine method of cesarean section was intraspinal anesthesia, and general anesthesia was only used for patients' strong demand, taboo, or failure of intraspinal anesthesia. According to the standard of intraoperative bleeding, the patients were divided into two groups: the obvious bleeding group (MH group, $N = 154$) and nonobvious hemorrhage group (NMH group, $N = 446$). The preoperative, intraoperative, and postoperative indexes of parturients in the two groups were analyzed and compared. Then, the risk factors of intraoperative bleeding were screened by logistic regression analysis with the occurrence of obvious bleeding as the dependent variable and the factors in the univariate analysis as independent variables. In order to further predict intraoperative blood transfusion, the standard cases of recesarean section and variables with possible clinical significance were included in the prediction model. Logistic regression, XGB, and ANN3 machine learning algorithms were used to construct the prediction model of intraoperative blood transfusion. The area under ROC curve (AUROC), accuracy, recall rate, and $F1$ value were calculated and compared. (2) According to whether hypothermia occurred in the anesthesia recovery room, the patients were divided into two groups: the hypothermia group ($N = 244$) and nonhypothermia group ($N = 356$). The incidence of hypothermia was calculated, and the relevant clinical data were collected. On the basis of consulting the literatures, the factors probably related to hypothermia were collected and analyzed by univariate statistical analysis, and the statistically significant factors were analyzed by multifactor logistic regression analysis to screen the independent risk factors of hypothermia in anesthetic convalescent patients. *Results*. (1) First of all, we compared the basic data of the blood transfusion group and the nontransfusion group. The gestational age of the transfusion group was lower than that of the nontransfusion group, and the times of cesarean section and pregnancy in the transfusion group were higher than those of the non-transfusion group. Secondly, we compared the incidence of complications between the blood transfusion group and the nontransfusion group. The incidence of pregnancy complications was not significantly different between the two groups ($P > 0.05$). The incidence of premature rupture of membranes in the nontransfusion group was higher than that in the transfusion group ($P < 0.05$). There was no significant difference in the fetal umbilical cord around neck, amniotic fluid index, and fetal heart rate before operation in the blood transfusion group, but the thickness of uterine anterior wall and the levels of Hb, PT, FIB, and TT in the blood transfusion group were lower than those in the nontransfusion group, while the number of placenta previa and the levels of

PLT and APTT in the blood transfusion group were higher than those in the nontransfusion group. The XGB prediction model finally got the 8 most important features, in the order of importance from high to low: preoperative Hb, operation time, anterior wall thickness of the lower segment of uterus, uterine weakness, preoperative fetal heart, placenta previa, ASA grade, and uterine contractile drugs. The higher the score, the greater the impact on the model. There was a linear correlation between the 8 features (including the correlation with the target blood transfusion). The indexes with strong correlation with blood transfusion included the placenta previa, ASA grade, operation time, uterine atony, and preoperative Hb. Placenta previa, ASA grade, operation time, and uterine atony were positively correlated with blood transfusion, while preoperative Hb was negatively correlated with blood transfusion. In order to further compare the prediction ability of the three machine learning methods, all the samples are randomly divided into two parts: the first 75% training set and the last 25% test set. Then, the three models are trained again on the training set, and at this time, the model does not come into contact with the samples in any test set. After the model training, the trained model was used to predict the test set, and the real blood transfusion status was compared with the predicted value, and the $F1$, accuracy, recall rate, and AUROC4 indicators were checked. In terms of training samples and test samples, the AUROC of XGB was higher than that of logistic regression, and the $F1$, accuracy, and recall rate of XGB of ANN were also slightly higher than those of logistic regression and ANN. Therefore, the performance of XGB algorithm is slightly better than that of logistic regression and ANN. (2) According to the univariate analysis of hypothermia during the recovery period of anesthesia, there were significant differences in ASA grade, mode of anesthesia, infusion volume, blood transfusion, and operation duration between the normal body temperature group and hypothermia group ($P < 0.05$). Logistic regression analysis showed that ASA grade, anesthesia mode, infusion volume, blood transfusion, and operation duration were all risk factors of hypothermia during anesthesia recovery. *Conclusion*. In this study, three machine learning algorithms were used to analyze the large sample of clinical data and predict the results. It was found that five important predictive variables of blood transfusion during recesarean section were preoperative Hb, expected operation time, uterine weakness, placenta previa, and ASA grade. By comparing the three algorithms, the prediction effect of XGB may be more accurate than that of logistic regression and ANN. The model can provide accurate individual prediction for patients and has good prediction performance and has a good prospect of clinical application. Secondly, through the analysis of the risk factors of hypothermia during the recovery period of cesarean section, it is found that ASA grade, mode of anesthesia, amount of infusion, blood transfusion, and operation time are all risk factors of hypothermia during the recovery period of cesarean section. In line with this, the observation of this kind of patients should be strengthened during cesarean section.

1. Introduction

Massive hemorrhage during cesarean section may lead to maternal death and other adverse outcomes [1]. Blood transfusion is an effective first-aid measure for massive hemorrhage during cesarean section. Previous studies have shown that the rate of blood transfusion during cesarean section ranges from 1.1% to 7.8% in developed countries and up to more than 12.2% in developing countries [2]. With the opening of the "two-child policy," the number of parturients undergoing recesarean section has increased year by year. Due to various complications such as placenta previa, placenta accreta, and intraoperative adhesion, the incidence of massive hemorrhage and blood transfusion during recesarean section has greatly increased [3]. It has been reported that the rate of blood transfusion in cesarean section increases with the increase of the number of cesarean sections, and the risk of blood transfusion in second cesarean section is significantly higher than that in primary cesarean section [4]. Although some risk factors of bleeding during cesarean section are known, there is still a lack of large sample clinical studies specifically for recesarean section. The prediction of intraoperative blood transfusion by anesthesiologists and obstetricians is mainly based on clinical experience, and there is still a lack of strong clinical evidence for reference. In addition, the amount of intraoperative bleeding is usually large and urgent, so it is necessary to further explore the risk factors of bleeding during recesarean section. The probability of maternal need for blood transfusion is evaluated and predicted in advance [5].

Normal body temperature is a necessary condition to ensure metabolism and normal life activities of the body [6]. Under normal circumstances, the human body maintains the balance between heat production and heat dissipation through the mechanism of autonomous and behavioral thermoregulation, keeping the body temperature constant at 36.5-37.5°C. In the course of operation, it is easy to cause the decrease of the patients' body temperature. The core body temperature below 36°C is called hypothermia [3]. A large number of studies have shown that [7–9] the incidence of perioperative hypothermia is high (50%-70%), and hypothermia will bring a variety of complications to patients, such as shivering, cardiovascular dysfunction, and coagulation dysfunction, which affect the recovery of patients, prolong hospital stay, and increase the financial burden of patients [9]. In recent years, with the wide application of computer technology in the medical and health industry, the degree of computerization of medical data has gradually increased. From prediction to diagnosis, from classification to classification, from severity assessment to prognosis assessment, machine learning methods have been applied to various fields. Compared with traditional statistical methods, machine learning algorithms do not have so strict restrictions on input data and output models and solve the problem of complex data modeling that cannot be solved by traditional statistics. Concomitantly, the classification performance of the machine learning algorithm model is quite good, and the results of using cross-validation to evaluate the performance are easy to be accepted by researchers [10]. Therefore, this study intends to use machine learning

Table 1: Clinical indicators.

Types	Index
Patient information	Age, BMI, number of cesarean sections, number of pregnancies, gestational weeks, history of abortion
Complication	Uterine leiomyoma, abnormal liver function, abnormal renal function, hyperthyroidism or hypothyroidism, gestational diabetes, gestational hypertension, eclampsia, placental abruption, premature rupture of membranes, threatened uterine rupture
Ultrasound results	Fetal umbilical cord around neck, thickness of lower segment of anterior wall of uterus, amniotic fluid index, placenta previa, fetal heart before operation
Test results	Hb, PLT, APTT, PT, TT, FIB
Anesthesia and intraoperative factors	Mode of anesthesia, ASA grade, operation time, placental adhesion, placental accreta, pelvic and abdominal adhesion, neonatal weight, uterine weakness

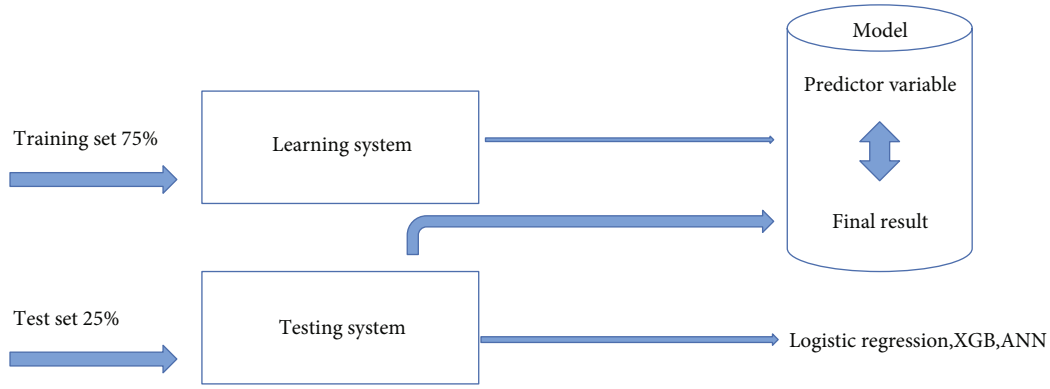

Figure 1: The process of machine learning.

algorithm to predict and evaluate the volume of blood transfusion during cesarean section and to explore and analyze the risk factors of hypothermia during anesthesia recovery.

2. Patients and Methods

2.1. Patient Information. Through the hospital electronic medical record of medical system, a total of 600 parturients who underwent cesarean section in our hospital from June 2019 to December 2020 were included. The maternal age, admission time, diagnosis, and other case data were recorded. The inclusion criteria were as follows: the age was from 20 to 45 years old, and the medical records were complete. The exclusion criteria were as follows: gestational age < 28 weeks, severe coagulation dysfunction, preoperative anticoagulation therapy, and complicated with hemorrhagic diseases. The routine method of cesarean section is intraspinal anesthesia, and general anesthesia is only used for patients' strong demand, taboo, or failure of intraspinal anesthesia. According to the intraoperative blood transfusion treatment, the patients were divided into two groups: the blood transfusion group ($n = 154$) and nonblood transfusion group ($n = 446$).

According to whether hypothermia occurred in the anesthesia recovery room, the patients were divided into two groups: the hypothermia group ($N = 244$) and nonhypothermia group ($N = 356$). The incidence of hypothermia was calculated, and the relevant clinical data were collected.

2.2. Inclusion of Variables and Outcomes. Based on literature retrieval and clinical experience [11, 12], the study included clinical indicators such as patient information, complications, ultrasound results, test results, anesthesia, and intraoperative factors, as detailed in Table 1. The main outcome of the study was intraoperative blood transfusion, including transfusion of red blood cells, plasma, and other blood products during cesarean section. At present, the standard of blood transfusion during cesarean section is not completely unified. Based on the guidelines and references [13], the blood transfusion guidelines during cesarean section in our hospital are as follows: (1) bleeding during cesarean section exceeds 1000 mL, (2) continuous bleeding with heart rate acceleration, (3) blood pressure drop and other vital signs need to be maintained by vasoactive drugs, and (4) hemoglobin is lower than 60 g/L.

2.3. Machine Learning. The study used machine learning method and supervised learning to learn from a large number of labeled cesarean section data to establish and train a model that can reflect the relationship between predictive variables and the outcome of blood transfusion. The machine learning process is shown in Figure 1. All 600 samples are divided into two parts, the first 75% is the training set, which is used to train and optimize the machine learning model, and the last 25% is used as the test set to test the final performance of the model. First of all, using the KFold method, the training set data is divided into five parts, which are assigned to five separate folders. Secondly, 11 machine

Table 2: Comparison of basic data between the blood transfusion group and nontransfusion group ($\bar{x} \pm s$).

Group	N	Age (years)	BMI (kg/m^2)	Gestational week (week)	Number of cesarean sections	Number of pregnancies
Blood transfusion group	154	31.95 ± 3.11	27.66 ± 2.44	36.79 ± 2.44	3.12 ± 0.56	4.51 ± 0.64
Nontransfusion group	446	31.77 ± 3.53	27.59 ± 2.32	38.81 ± 2.44	2.19 ± 0.34	3.16 ± 0.44
t		0.561	0.318	8.857	24.402	28.953
P		0.574	0.750	≤0.001	≤0.001	≤0.001

Table 3: Comparison of complications between the blood transfusion group and nontransfusion group (n (%)).

Group	Blood transfusion group ($n = 154$)	Nontransfusion group ($n = 446$)	χ^2	P
Pregnancy complicated with uterine leiomyoma	4 (2.70)	17 (3.90)	0.499	0.497
Abnormal liver function	15 (9.60)	34 (7.60)	0.684	0.408
Abnormal renal function	1 (0.65)	2 (0.50)	0.092	0.760
Hyperthyroidism/hypothyroidism	4 (2.70)	17 (3.80)	0.499	0.497
Gestational diabetes mellitus	23 (15.10)	78 (17.50)	0.533	0.462
Gestational hypertension	4 (2.70)	18 (4.10)	0.670	0.412
Eclampsia	4 (2.70)	10 (2.30)	0.063	0.801
Abruption of membranes	1 (0.65)	2 (0.50)	0.092	0.760
Premature rupture of membranes	8 (5.40)	52 (11.70)	5.315	0.021
Threatened uterine rupture	12 (7.50)	28 (6.30)	0.421	0.516

learning algorithms, such as linear regression, linear discrimination, nearest neighbor, decision tree, naive Bayesian, support vector machine, Ada lifting, random forest, extreme tree, and gradient lifting decision tree, are trained and evaluated in turn in each fold. Finally, the cross_val_score method in the machine learning framework scikit-learn is used for cross-verification to observe the comprehensive performance of different algorithms. Finally, according to the performance of the algorithm, the final models of logistic regression, XGB, and ANN3 are selected.

2.4. Statistical Analysis. SPSS 19.0 software was used for statistical analysis. The measurement data of normal distribution were expressed by mean ± standard deviation, the comparison between groups was performed by two independent sample t-tests, the measurement data of skewness distribution was expressed by median (M) and quartile spacing (IQR), and the comparison between groups was expressed by Mann–Whitney U test/rank sum test. The counting data were compared by χ^2 test. Logistic regression analysis was used to analyze the risk factors of hypothermia during the recovery period of anesthesia.

3. Results

3.1. Comparison of Basic Data between Blood Transfusion Group and Nontransfusion Group. First of all, we compared the basic data of the blood transfusion group and the nontransfusion group, there was no significant difference in age and BMI between the two groups, but the gestational age of the transfusion group was lower than that of the nontransfusion group, and the times of cesarean section and pregnancy in the transfusion group were higher than those in the nontransfusion group ($P < 0.05$). All the results are shown in Table 2.

3.2. Comparison of Complications between Blood Transfusion Group and Nontransfusion Group. Secondly, we compared the incidence of complications between the blood transfusion group and the nontransfusion group. There was no significant difference in the incidence of pregnancy complicated with hysteromyoma, abnormal liver function, abnormal renal function, hyperthyroidism/hypothyroidism, gestational diabetes mellitus, gestational hypertension, eclampsia, abruption of membranes, premonitory uterine rupture, and complications between the two groups ($P > 0.05$). The incidence of premature rupture of membranes in the nontransfusion group was significantly higher than that in the transfusion group ($P < 0.05$). All the data are shown in Table 3.

3.3. Comparison of Ultrasonic Indexes and Preoperative Examination Indexes between Blood Transfusion Group and Nonblood Transfusion Group. Next, we compared the ultrasonic indexes and preoperative examination between the blood transfusion group and the nontransfusion group. The results showed that there was no significant difference in the umbilical cord around the neck, amniotic fluid index, and fetal heart before operation in the transfusion group, but the thickness of the anterior wall of uterus; the levels of Hb, PT, FIB, and TT in the transfusion group were lower than those in the nontransfusion group; and the number of placenta previa and the levels of PLT and APTT in the transfusion group were significantly higher than those in the

nontransfusion group ($P < 0.05$). All the results are shown in Table 4.

3.4. Machine Learning Results. We analyzed the linear correlation between the machine learning results and the 8 features obtained by the XGB prediction model. The XGB prediction model finally obtained the 8 most important features, in the order of importance from high to low as follow: preoperative Hb, operation time, anterior wall thickness of the lower segment of the uterus, uterine weakness, preoperative fetal heart, placenta previa, ASA grade, and uterine contraction promoting drugs. The higher score, the greater impact on the model. There was the correlation between the 8 features (including the correlation with the target blood transfusion). The indexes with strong correlation with blood transfusion included placenta previa, ASA grade, operation time, uterine atony, and preoperative Hb. Placenta previa, ASA grade, operation time, and uterine atony were positively correlated with blood transfusion, while preoperative Hb was negatively correlated with blood transfusion ($P < 0.05$). All the results are shown in Table 5.

3.5. Comparison of Predictive Ability of Three Machine Learning Methods. In order to further compare the prediction ability of the three machine learning methods, all the samples were randomly divided into two parts: the first 75% training set and the last 25% test set. Then, the three models were trained again on the training set, and at this time, the model did not come into contact with the samples in any test set. After the model training, the trained model was used to predict the test set, and the real blood transfusion status was compared with the predicted value, and the $F1$, accuracy, recall rate, and AUROC4 indicators were checked. In terms of training samples and test samples, the AUROC of XGB was higher than that of logistic regression, and the $F1$, in contrast, accuracy, and recall rate of XGB of ANN were also slightly higher than those of logistic regression and ANN ($P < 0.05$). Therefore, the performance of XGB algorithm was slightly better than that of logistic regression and ANN. All the results are shown in Table 6.

3.6. Single-Factor Analysis of Hypothermia during Anesthesia Recovery Period. Then, we analyzed the univariate analysis of hypothermia during the recovery period of anesthesia. There were significant differences in ASA grade, anesthetic mode, infusion volume, blood transfusion, and operation duration between the normal body temperature group and hypothermia group ($P < 0.05$). There was no significant difference in operating room temperature and the use of vasoactive drugs between the two groups ($P > 0.05$). All the results are shown in Table 7.

3.7. Logistic Regression Analysis of Hypothermia during Anesthesia Recovery. Finally, we analyzed the risk factors of hypothermia during anesthesia recovery. Logistic regression analysis showed that ASA grade, anesthesia mode, infusion volume, blood transfusion, and operation duration were all risk factors of hypothermia during anesthesia recovery ($P < 0.05$). All the results are shown in Table 8.

4. Discussion

With the continuous development and progress of obstetrics, anesthesia, and blood transfusion technology, cesarean section and anesthesia technology continue to develop, and the safety of cesarean section has been improved greatly [2]. In the past, due to the lax grasp of cesarean section guidelines and the influence of some social factors, the rate of cesarean section in China has been rising all the way to the forefront of the world. In recent years, under the guidance of national and local "guidelines for strict control of cesarean section," the rate of cesarean section in China has declined. However, after the full liberalization of the two-child policy in 2015, more and more women have the second child with the increasing number of women with scar uterus [14]. Compared with the first cesarean section, the second cesarean section has more operation time and probabilities of complications such as intraoperative hemorrhage significantly increased [15]. However, cesarean section is often an emergency operation and there is not enough preparation time before operation. If massive hemorrhage occurs during recesarean section, it is often more urgent. In the process of rescuing massive hemorrhage, in addition to taking effective hemostatic measures according to the causes of bleeding, timely massive transfusion of blood products is also the key to successful rescue [15]. Therefore, it has been the goal of clinical anesthesiologists to analyze the causes of blood transfusion during recesarean section and to adopt safe and effective perioperative bleeding prevention and blood management strategies. The main purpose of blood transfusion is to improve the oxygen-carrying capacity of blood, maintain blood perfusion of important organs of parturients, supplement coagulation factors, and so on. Intraoperative blood transfusion should be combined with the clinical practice of parturients, strictly grasp the indications of blood transfusion, make blood transfusion timely and reasonable, and, at the same time, minimize the complications related to blood transfusion and unnecessary waste of blood products [15].

Previous studies have indicated that the rate of blood transfusion during cesarean section ranges from 1.1% to 7.8% in developed countries and up to more than 12.2% in developing countries [16]. In a retrospective study of patients undergoing blood transfusion after cesarean section, Abbas et al. pointed out that the main causes of blood transfusion are uterine weakness, scarred uterus, placental adhesion, placenta accreta, prenatal anemia, placenta previa, and so on [17]. Pont et al. found that the increase of blood transfusion rate during cesarean section after the opening of the comprehensive "two-child policy," ASA grade III-IV, operation time longer than 60 min, and preoperative complications were independent risk factors for blood transfusion during cesarean section [18]. He et al. proposed that placenta previa is the primary risk factor for intraoperative blood transfusion for second cesarean section, and women with placenta previa have a higher probability of intraoperative blood transfusion [19]. Abdelaleem et al. also proposed that after the implementation of the "two-child policy", placenta previa becomes one of the serious complications,

Table 4: Comparison of ultrasonic indexes and preoperative examination indexes between the blood transfusion group and nontransfusion group ($\bar{x} \pm s, n(\%)$).

Group	Blood transfusion group ($n = 154$)	Nontransfusion group ($n = 446$)	t/χ^2	P
Ultrasonic index				
Fetal umbilical cord around neck	23 (14.93)	67 (15.02)	0.000	0.979
Thickness of the lower segment of the anterior wall of the uterus(mm)	1.32 ± 0.53	1.68 ± 0.64	6.257	≤0.001
Amniotic fluid index(mm)	120.96 ± 38.92	116.94 ± 34.32	1.209	0.226
Placenta previa	120 (7.92)	10 (2.24)	386.302	≤0.001
Preoperative fetal heart rate	142.93 ± 6.67	143.82 ± 6.53	1.450	0.147
Preoperative test index				
Hb ($g \cdot dL^{-1}$)	10.01 ± 1.45	11.98 ± 1.45	14.536	≤0.001
PLT ($10^9 \cdot L^{-1}$)	186.83 ± 53.32	175.81 ± 44.67	2.506	0.012
PT (s)	9.38 ± 0.77	10.53 ± 0.67	17.654	≤0.001
FIB ($g \cdot L^{-1}$)	4.16 ± 0.65	4.85 ± 0.86	9.097	≤0.001
APTT (s)	28.91 ± 2.42	26.83 ± 1.33	13.264	≤0.001
TT (s)	17.02 ± 0.45	17.92 ± 0.32	26.913	≤0.001

Table 5: Linear correlation among eight features obtained by XGB prediction model.

Variable	r	P
Placenta previa	0.663	<0.05
ASA grading	0.894	<0.05
Operation time	0.812	<0.05
Uterine weakness	0.855	<0.05
Before operation Hb	-0.655	<0.05

which often leads to unpredictable intraoperative bleeding, significantly increases the intraoperative blood transfusion rate and hysterectomy rate, and seriously threatens the safety of mothers and infants [20]. The causes of blood transfusion during recesarean section mainly include placental factors such as placenta previa, placental adhesion, placental accreta, prenatal anemia, scar uterus and other preoperative complications, uterine weakness, intraoperative adhesion, and prolonged operation time. Placental factors such as placenta previa are still the main influencing factors of intraoperative blood transfusion. The study found that more than 50% of cesarean section women with placenta previa underwent intraoperative blood transfusion [21]. Previous studies have suggested that uterine weakness is the main cause of perioperative hysterectomy. However, current studies have found that placental abnormalities have exceeded uterine weakness in developed countries and become the leading cause of hysterectomy [22, 23]. This may be due to changes in obstetrical practice and the development of obstetrical patients, including an increase in the number of older women, higher rates of maternal obesity, and increasing rates of cesarean sections and abortions.

It was reported in the 1980s that the incidence of hypothermia in anesthesia recovery room was as high as 60% [24]. In recent years, with the development of accelerated rehabilitation surgery and the further promotion of high-quality nursing, people pay more and more attention to the protection of perioperative body temperature, and the incidence of hypothermia has changed to a certain extent. In 2016, some scholars reported that [25]. Some institutions require patients with anesthesia time of more than 30 minutes to monitor their body temperature and use heat preservation measures to keep their body temperature above 36°C both during the operation and during the recovery period [26]. The body temperature protection measures are mainly active heat preservation and a variety of heat preservation. The common use of composite thermal insulation is mainly inflatable heating blanket is currently recognized as the most safe and effective and widely used body temperature protection measures [27]. Through the preservation of anesthesia recovery room before, during and after operation, the long-term prognosis of patients has been significantly improved. However, although a relatively mature body temperature protection system has been formed in developed countries, routine body temperature monitoring has not been achieved in most developing countries, and body temperature protection measures are mostly limited to passive heat preservation. The limited quantity and uneven distribution of health resources may be an important reason for this phenomenon. Therefore, to evaluate the risk of hypothermia and make efficient use of limited health resources is an important way to solve the problem at this stage.

Machine learning (ML) is a subject of artificial intelligence, which can improve the performance of specific algorithms in empirical learning, which is a method to train a model by using data, and then use the model to predict [27]. It has been widely used in the field of medicine, including dealing with a large number of potential data in complex modern electronic medical records (EMR). ML can obtain practice-based longitudinal data sets from large electronic

Table 6: Comparison of predictive ability of three machine learning methods.

Data	Model	$F1$	Accuracy	Recall rate	AUROC
All samples ($n = 600$)	Logistic return	0.949	0.873	0.753	0.969
	XGB	0.962	0.879	0.759	0.964
	ANN	0.951	0.841	0.781	0.954
Training sample ($n = 450$)	Logistic return	0.952	0.958	0.958	0.814
	XGB	0.966	0.968	0.965	0.906
	ANN	0.961	0.959	0.969	0.889
Test sample ($n = 150$)	Logistic return	0.951	0.950	0.943	0.828
	XGB	0.953	0.954	0.965	0.881
	ANN	0.951	0.957	0.955	0.885

Table 7: Single-factor analysis of hypothermia during anesthesia recovery.

Group	Normal body temperature group ($n = 356$)	Hypothermia group ($n = 244$)	χ^2	P
ASA grading				
I & II	321 (90.17)	237 (97.13)	10.780	0.001
III & IV	35 (9.83)	7 (2.87)		
Anesthetic mode				
Intraspinal anesthesia	344 (96.63)	205 (84.02)	29.612	≤0.001
General anesthesia	12 (3.37)	39 (15.98)		
Room temperature (°C)				
22-23	135 (37.92)	103 (42.21)	1.114	0.291
>24	221 (62.08)	141 (57.79)		
Infusion volume (mL)				
≤1000	204 (57.30)	95 (38.93)	19.539	≤0.001
>1000	152 (42.70)	149 (61.07)		
Blood transfusion				
Yes	64 (17.98)	90 (36.89)	27.127	≤0.001
No	292 (82.02)	154 (63.11)		
Vasoactive drugs				
Use	152 (42.70)	123 (50.41)	3.469	0.062
Not used	204 (57.30)	121 (49.59)		
Operation time				
<60 min	284 (79.78)	155 (63.52)	19.473	≤0.001
≥60 min	72 (20.22)	89 (36.48)		

Table 8: Logistic regression analysis of hypothermia during anesthesia recovery.

Variable	b	S.E	Chi-square value	P	OR	95% CI for OR
ASA grading	-1.344	0.143	88.334	≤0.001	0.261	0.197-0.345
Anesthetic mode	2.454	1.214	4.086	0.043	11.635	1.077-125.642
Infusion volume	3.255	1.052	9.573	0.002	25.920	3.297-203.755
Blood transfusion	4.223	0.316	178.594	≤0.001	68.238	36.732-126.768
Operation time	3.254	0.321	102.760	≤0.001	25.894	13.802-48.577

medical records and serve the clinic, especially clinical risk prediction, through the automatically improved computer algorithms [28]. At present, ML is more and more widely used in anesthesia. It can help anesthesiologists to make objective prediction and judgment by analyzing, calculating, and predicting a large amount of data in clinical medical records and anesthesia records. Compared with traditional statistical methods, ML model can provide patients with more accurate individual prediction and better prediction performance [18]. In our study, the parturients undergoing

second cesarean section were selected to screen the risk factors of intraoperative bleeding, and tendency matching (PSM) was used to compare the effects of anesthesia on intraoperative bleeding and related outcomes. Then, the prediction model of intraoperative blood transfusion was constructed by three kinds of machine learning algorithms, and the prediction effects of artificial neural network (ANN), extreme gradient lifting (XGB), and logical regression (LR) on blood transfusion during recesarean section were analyzed and compared, in order to explore a new idea of intraoperative blood transfusion prediction and help anesthesiologists and obstetricians to identify parturients who need blood transfusion in advance [29]. As a result, intervention measures such as blood transfusion should be taken in time to improve the perioperative safety of parturients and fetuses. XGB is a popular integrated learning algorithm at present, and its biggest feature is that it can automatically use the multithread of CPU for parallel, and it is not easy to over-fit. Meanwhile, the algorithm is proved to improve the accuracy. It is not a single machine learning algorithm, it can train multiple learners and combine them and finally get a strong learner, in order to achieve the purpose of learning from others. Ensemble learning is mainly applied to classification problem integration, regression problem integration, feature selection integration, outlier detection integration, and so on. It can be acknowledged that all machine learning can see the shadow of ensemble learning [30–32].

Taken together, three machine learning algorithms were used to process and analyze the clinical data of large samples of cesarean section and predict the results. It was found that five important predictive variables of blood transfusion during re-cesarean section were preoperative Hb, expected operation time, uterine atony, placenta previa, and ASA grade. By comparing the three algorithms, it is found that the three machine learning algorithms logistic regression, XGB, and ANN can be used to predict blood transfusion during cesarean section, and the prediction effect of XGB may be more accurate than that of logistic regression and ANN. The model can provide accurate individual prediction for patients, has good prediction performance, and has a good prospect of clinical application. Furthermore, through the analysis of the risk factors of hypothermia during the recovery period of cesarean section, it is found that ASA grade, mode of anesthesia, amount of infusion, blood transfusion, and operation time are all risk factors of hypothermia during the recovery period of cesarean section. In view of this, the observation of this kind of patients should be strengthened during cesarean section.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest

Authors' Contributions

Wei Ren and Danmei Li have contributed equally to this work and share first authorship.

References

[1] Y. Lixia, K. Shanshan, and S. Haiyan, "Research progress of intraoperative hypothermia in women undergoing cesarean section," *Journal of Nursing*, vol. 36, no. 22, pp. 103–106, 2021.

[2] Z. Xiaoyun and Z. Ningning, "Effect of combined intervention of warming infusion and environmental warming on psychology and pregnancy outcome of hypothermic parturients undergoing cesarean section," *Maternal and child health care in China*, vol. 36, no. 20, pp. 4669–4671, 2021.

[3] T. Miao and Z. Xiaoyun, "Effect of radiator to prevent hypothermia on the rehabilitation of patients undergoing cesarean section," *Maternal and child health care in China*, vol. 36, no. 15, pp. 3632–3636, 2021.

[4] C. Chiara, M. Roberta, and D. M. Daniele, "Maternal outcomes of cesarean delivery performed at early gestational ages: a systematic review and meta-analysis," *American Journal of Obstetrics & amp; Gynecology MFM*, vol. 3, no. 4, pp. 56–69, 2021.

[5] D. G. Raffaella, G. Carmen, and B. Danilo, "Outcomes of second stage cesarean section following the use of a fetal head elevation device: a systematic review and meta-analysis," *European Journal of Obstetrics & amp; Gynecology and Reproductive Biology*, vol. 262, no. 55, pp. 48–51, 2021.

[6] P. Vasilios, M. Dimitra, and B. Eirini, "Cephalad-caudad versus transverse blunt expansion of the low transverse hysterotomy during cesarean delivery decreases maternal morbidity: a meta-analysis," *American Journal of Obstetrics and Gynecology*, vol. 225, no. 2, pp. 67–70, 2021.

[7] K. Shanshan, L. Deng, and S. Haiyan, "Study on the construction and application effect of risk prediction model of intraoperative hypothermia in women undergoing cesarean section," *Chinese Journal of Nursing*, vol. 56, no. 2, pp. 165–171, 2021.

[8] E. Attali, D. Epstein, L. Reicher, M. Lavie, Y. Yogev, and L. Hiersch, "Mild thrombocytopenia prior to elective cesarean section is an independent risk factor for blood transfusion," *Archives of Gynecology and Obstetrics*, vol. 304, no. 3, pp. 627–632, 2021.

[9] Z. Yao, M. Ning-Ye, and P. Xiao-Ao, "Uterine incision dehiscence 3 mo after cesarean section causing massive bleeding: a case report," *World Journal of Clinical Cases*, vol. 8, no. 11, pp. 634–637, 2020.

[10] C. Hong, T. Hua, and L. Pei-Xin, "Comparison of cell salvage with one and two suction devices during cesarean section in patients with placenta previa and/or accrete: a randomized controlled trial," *Chinese Medical Journal*, vol. 53, no. 33, pp. 263–266, 2020.

[11] C. Liang, T. Yujie, and Y. Jianyin, "Retrospective analysis of the application of recovered autotransfusion during cesarean section in patients at high risk of postpartum hemorrhage," *Chinese Journal of Physicians*, vol. 22, no. 2, pp. 263–266, 2020.

[12] K. Jieun, K. H. Sim, and L. E. Bi, "Prediction model for massive transfusion in placenta previa during cesarean section," *Yonsei Medical Journal*, vol. 61, no. 2, pp. 154–679, 2020.

[13] H. Ya-Ching, R. Shah Harsh, and B. Pradeep, "The association of race with outcomes among parturients undergoing cesarean

section with perioperative epidural catheter placement: a nationwide analysis," *Cureus*, vol. 12, no. 1, pp. 665–669, 2020.

[14] I. Mai, O. Kensuke, and T. Kazuyuki, "Massive obstetric hemorrhage during cesarean section in a patient after conception by frozen-thawed embryo transfer: a case report," *JA clinical reports*, vol. 6, no. 1, pp. 552–558, 2020.

[15] S. Laura, D. la Calle, and M. F. Maria, "Efficacy of carbetocin for preventing postpartum bleeding after cesarean section in twin pregnancy," *The journal of maternal-fetal & amp; neonatal medicine: the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies the International Society of Perinatal Obstetricians*, vol. 33, no. 2, pp. 267–271, 2020.

[16] L. Jie, D. Guangyou, and Z. Yi, "Comparative analysis of artificial neural network, extreme gradient lifting and logistic regression for predicting blood transfusion during re-cesarean section," *Journal of the third military Medical University*, vol. 41, no. 24, pp. 2430–2437, 2019.

[17] A. Shahida, M. Saba, H. S. N. Fatima, and H. Nazli, "Blood transfusion and high-order cesarean delivery; report from a developing country," *Pakistan journal of medical sciences*, vol. 35, no. 6, pp. 664–668, 2019.

[18] S. Pont, K. Austin, and I. Ibiebele, "Blood transfusion following intended vaginal birth after cesarean versus elective repeat cesarean section in women with a prior primary cesarean: a population-based record linkage study," *Obstetric Anesthesia Digest*, vol. 39, no. 4, pp. 564–569, 2019.

[19] Q. He, L. Ying-Long, and M.-J. Zhu, "Prophylactic abdominal aortic balloon occlusion in patients with pernicious placenta previa during cesarean section: a systematic review and meta-analysis from randomized controlled trials," *Archives of gynecology and obstetrics*, vol. 300, no. 5, pp. 566–569, 2019.

[20] A. Abdelaleem Ahmed, M. Abbas Ahmed, and L. Thabet Andrew, "The effect of initiating intravenous oxytocin infusion before uterine incision on the blood loss during elective cesarean section: a randomized clinical trial," *The journal of maternal-fetal & amp; neonatal medicine: the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians*, vol. 32, no. 22, pp. 451–459, 2019.

[21] H. Abdullahi, M. Yusuf, and A. Dayyabu, "Deep tongue laceration following eclampsia, cesarean section, repair and blood transfusion- a case report," *Tropical Journal of Obstetrics and Gynaecology*, vol. 36, no. 3, pp. 456–459, 2019.

[22] Y. Wang, L. Siyuan, and L. He, "Prophylactic use of tranexamic acid reduces blood loss and transfusion requirements in patients undergoing cesarean section: a meta-analysis," *The Journal of Obstetrics and Gynaecology Research*, vol. 45, no. 8, pp. 41–49, 2019.

[23] K. Yamamoto, A. Suzuki, M. Shimaoka, Y. Yo, M. Mandai, and N. Matsumura, "Severe fatty liver of pregnancy requiring an extremely large amount of blood transfusion, surgery and transarterial embolization: a case report," *Case Reports in Women's Health*, vol. 23, no. 12, 2019.

[24] X. Xiaohan, Y. Zhang, and Y. Xuerong, "Preoperative moderate thrombocytopenia is not associated with increased blood loss for low-risk cesarean section: a retrospective cohort study," *BMC Pregnancy and Childbirth*, vol. 19, no. 1, pp. 675–679, 2019.

[25] M. Tasuku, U. Mina, and S. Naoko, "Recurrent massive uterine bleeding from a cesarean scar treated successfully by laparoscopic surgery," *Gynecology and minimally invasive therapy*, vol. 8, no. 1, pp. 564–569, 2019.

[26] N. Zahra, S. Sara, and K. Elham, "Risk factors and clinical significance of abdomino-pelvic free fluid after cesarean section: a prospective study," *The journal of maternal-fetal & amp; neonatal medicine: the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies the International Society of Perinatal Obstetricians*, vol. 64, no. 44, pp. 156–159, 2019.

[27] N. Shohei, M. Takeshi, and K. Hiroko, "Embryo transfer is a risk factor for severe postpartum hemorrhage and blood transfusion requirement," *The journal of maternal-fetal & amp; neonatal medicine: the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies the International Society of Perinatal Obstetricians*, vol. 32, no. 6, pp. 879–882, 2019.

[28] P. Sarah, A. Kathryn, and I. Ibinabo, "Blood transfusion following intended vaginal birth after cesarean vs elective repeat cesarean section in women with a prior primary cesarean: a population-based record linkage study," *Acta Obstetricia et Gynecologica Scandinavica*, vol. 98, no. 3, pp. 156–159, 2019.

[29] M. Ruijing, Z. Kan, and Z. Qingsong, "Retrospective analysis of risk factors of blood transfusion and neonatal outcome during cesarean section," *Chinese Journal of Anesthesiology*, vol. 3, pp. 365–368, 2019.

[30] A. Ahmed, M. Al-Sayed Helmy, and M. Ibrahim Ahmed, "Urinary tract injuries during cesarean section in patients with morbid placental adherence: retrospective cohort study," *The journal of maternal-fetal & amp; neonatal medicine: the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians*, vol. 32, no. 9, pp. 56–59, 2017.

[31] C. Qinjun, S. Dan, and H. Long, "Anesthetic management of cesarean section in cases of placenta accreta, with versus without abdominal aortic balloon occlusion: study protocol for a randomized controlled trial," *Trials*, vol. 18, no. 1, pp. 144–149, 2017.

[32] M. Khooshideh and T. Mirzarahimi, "The comparison of maternal and neonatal outcomes of normal vaginal delivery versus unplanned cesarean section delivery," *Journal of Ardabil University of Medical Sciences*, vol. 17, no. 1, pp. 167–169, 2017.