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Analysis of the Effectiveness of Day Surgery for Pediatric Syringomyelia and Construction of a Predictive Model for Delayed Discharge Risk

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Keywords: Traffic sheath effusion; Day surgery; Delayed discharge; Prediction model

Abstract: To explore the efficacy of pediatric CH under day surgery mode, the risk associated with delayed discharge, construct a risk prediction model about its delayed discharge and conduct internal validation, to improve more reasonable diagnosis and treatment advice for children with CH and enhance the communication between doctors and patients; This study retrospectively reviewed the data of 89 children who had been operated in the Day Surgery Ward and the Urology Specialized Ward of Hunan Provincial People's Hospital and who had been diagnosed with CH after surgery. The data of 89 children were retrospectively reviewed, and CH was managed by performing surgical procedures with or without drainage according to two clinical pathways: day surgery and urology. The follow-up of the children in the perioperative period, 1 week and 3-6 months after discharge, and the satisfaction survey were examined. In this way, the efficacy and safety of children with CH in the day surgery mode were evaluated. At the same time, we analyzed the preoperative and intraoperative conditions of children with CH who were discharged normally and delayed in the outpatient surgery ward, screened the risk factors related to delayed discharge using lasso logistic regression analysis, constructed a prediction model of delayed discharge risk based on R language, drew nomogram plots to visualize the model, and internally verified the predictive efficacy of the model; By means of lasso logistic regression analysis, we screened: Age, BMI, neutrophil count, anesthesia time, and blood potassium as risk factors for delayed discharge.

1. Introduction

Traffic hydrocele (CH) is a prevalent pediatric urological disease, with a significantly higher incidence observed in male infants, with a prevalence rate of 0.7-4.7%. It is defined as an abnormal accumulation of fluid in the sheath cavity on the affected side, which may not be caused by The term "sheath" is used to describe an abnormal accumulation of fluid in the lumen of the affected testicular sheath[1]. This accumulation may not be caused by syringomyelia. The size of the scrotal swelling may vary depending on the position of the affected testicle. This condition is usually diagnosed through physical examination or ultrasound imaging[2]. The surgical treatment of CH hinges on the excision and ligation of the unclosed syringomyelia, as well as the excision or reversal of the spermatic cord and testicular sheath[3].The implementation of day surgery has the potential to markedly enhance the quality of life for patients. The ability to perform surgery and treatment within 24 hours not only saves a significant amount of medical resources but also greatly reduces the length of hospitalization, thereby lowering the financial burden on patients and enhancing the efficiency of medical services[4]. In some cases, patients undergoing day surgery are unable to be discharged from the hospital at the originally scheduled time due to unforeseen circumstances, such as alterations in surgical techniques, postoperative complications, or anesthesia-related issues. In cases where the hospitalization period exceeds 24 hours and the patient requires transfer to a specialized ward for continued treatment, this is referred to as a "delayed discharge"[5]. This article is concerned with the efficacy of pediatric CH in day surgery mode and the risks associated with delayed discharge. A retrospective analysis of children's clinical data and other information was conducted to evaluate the efficacy and safety of this treatment modality. Additionally, a predictive model for delayed discharge was developed and internally validated to assess the predictive efficacy of the model.

2. Subjects and Methods

2.1 Subjects

A convenience sampling method was employed in this study, which was conducted to retrospectively collect the clinical data of children who underwent surgical treatment and were diagnosed with CH postoperatively from January 2021 to December 2022 in this hospital. The inclusion and exclusion criteria were applied to screen 89 children with CH, who were thus identified as the study subjects. The subjects were divided into two groups: the daytime group (n=43) and the urology group (n=46). This division was based on the clinical pathways of daytime surgery and urology surgery. All of the surgeons were at the level of deputy director or above and had completed at least 50 CH surgeries. In the ambulatory group, children with CH underwent preoperative preparation and rapid postoperative rehabilitation in accordance with the ERAS concept. Inclusion criteria: a. All children with CH who were older than 2 years old and not older than 14 years old participated in the study; b. Comprehensive clinical information and follow-up records were available, including preoperative blood tests, ultrasonography, surgical procedures, recovery, and post-discharge follow-up and satisfaction surveys; c. The American Society of Anesthesiologists (ASA) had a complete list of all the patients who had undergone CH surgery in the daytime group. Anesthesiology (ASA) score: Grade I-II[6]. d. Onset on one side only and undergoing surgery for the first time. The exclusion criteria included the following: a. Children with bilateral morbidity; b. Previously treated with surgery, now needing reoperation for postoperative recurrence; c. Preoperative ultrasound suggesting the combination of inguinal hernia, cryptorchid testis, and other diseases; d. Combined with other systemic serious diseases; e. Cases who refused this follow-up survey and lost the visit.

2.2 Methods

A retrospective survey method was employed to collect data from pediatric subjects, including preoperative data (general clinical data and biochemical data, ultrasound data, etc.), intraoperative data (length of surgery, anesthesia time, etc.), and postoperative occurrence of various adverse reactions.

2.3 Diagnostic criteria

The postoperative diagnosis by the attending surgeon was used as the diagnostic criterion for CH, with reference to the definition provided by Campbell in the field of urology[2]. CH occurs when the syringomyelia has not completely closed and when fluid in the testicular sheath is accessible from the abdominal cavity and flows between the abdominal and syringomyelia cavities in response to changes in body position.

2.4 Statistical processing

All data were subjected to statistical analysis using SPSS 25.0 and R (4.2.1) software. The Kolmogorov-Smirnov test (K-S test) was employed to ascertain whether the continuous variables were distributed normally. For variables that exhibited a normal distribution, the mean ± standard deviation (Mean ± SD) was used to express the data. For variables that did not conform to a normal distribution, the median (M) and the 25th and 75th percentiles (P25, P75) were used to express the data. Continuous variables with a normal distribution and variance that satisfied the chi-square test were evaluated using t-tests. Non-normal distributions were assessed using Mann-Whitney U nonparametric rank sums. Comparisons between groups were conducted using frequencies (%), for categorical data, and the chi-square test and Fisher's exact test. The issue of data covariance was addressed through the use of Lasso regression, as facilitated by the "glmnet" package of R (4.2.1) software. Additionally, the potential for overfitting was mitigated through the incorporation of a penalty mechanism. Some of the risk variables were identified as potential risk factors and subjected to further analysis using multifactor logistic regression equations. A delayed discharge risk prediction model was constructed using the R (4.2.1) software "rms" package, based on the Lasso-Logistic screening results. A nomogram was subsequently generated to facilitate visualisation of the model. The internal validation of the model is as follows: 1. Calibration was conducted using bootstrap to generate 1,000 random samples of the model, which were used to test the consistency of the model and calculate the consistency index (C-index) of the model. The C-index is a measure of the reliability and usability of the model. Differentiation was achieved by plotting the receiver operating characteristic (ROC) curve and then plotting the nomogram. Additionally, the receiver operating characteristic (ROC) curve and the area under the curve (AUC) were calculated. In order to assess the clinical applicability of the model, a clinical decision curve analysis (DCA) was conducted to evaluate the predictive ability of the model. The results of multiple statistical tests were all found to be statistically significant with a p-value less than 0.05.

3. Results

3.1 General information

After screening the data with inclusion and exclusion criteria, the medical records of 89 children with CH were enrolled in the study. Of these, 43 children with CH were enrolled in the daytime group and 46 children with CH were enrolled in the urinary group. The children's information was obtained from the hospital's electronic medical record (EMR) system and electronic medical prescription (EMP) system. The children's preoperative clinical information, including age, height, and weight, was recorded. Routine preoperative blood tests were conducted on all subjects, with the exception of those in the urology group, who underwent testing after being hospitalized. The tests included hemoglobin, leukocytes, neutrophils, and blood potassium. The preoperative waiting time for surgery (H1), the surgical time (H2), and the anesthesia time (H3) were recorded. The occurrence of postoperative adverse reactions (postoperative vomiting, postoperative fever, postoperative pain, postoperative bleeding, incision infection), and their observation or treatment, the transfer of children to urology wards after surgery in the daytime group (yes/no), the time of postoperative discharge (H4), the total length of hospitalization (H5), the total cost of hospitalization, and the degree of satisfaction. A postoperative fever was defined as an increase of 1°C or ≥37.5°C from the admission standard temperature, with a return to 36.8°C considered normal[7]. Postoperative pain was measured using the Visual Analogue Scale (VAS) score was employed as the most prevalent pain measurement instrument in clinical practice at the time of the study. The Freiburg Index of Patient Satisfaction (FIPS) was utilized to gauge satisfaction one week following hospital discharge[8]. Follow-up assessments were conducted. The results demonstrated statistically significant discrepancies between the two groups with regard to white blood cell count, neutrophils, preoperative waiting time, postoperative vomiting, postoperative length of stay, total length of stay, total cost, and satisfaction at the one-week post-discharge follow-up (P < 0.05). For further details, please refer to Table 1.

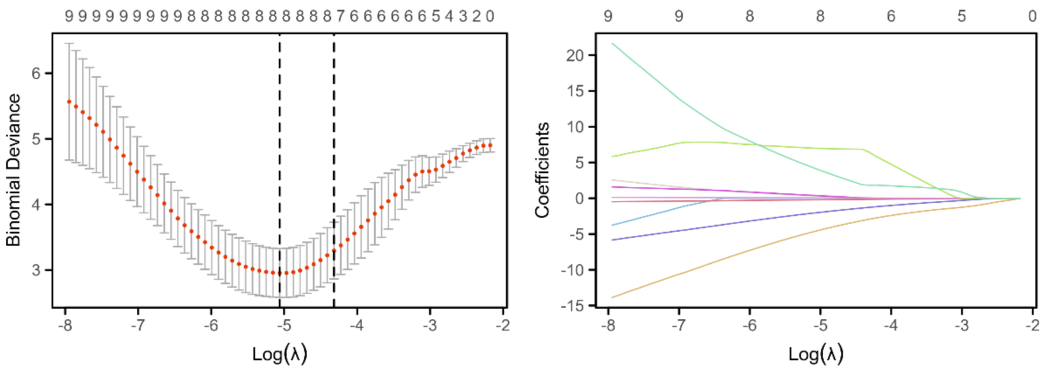
Table 1: Comparison of children in the daytime and urinary groups

Statistic	**Cluster results**		**χ2/Z**	***P***
	Daytime group (43 cases)	**Urinary group (46 cases)**		
Age (years)	5.5 (3.85,6.55)	5.6 (3.6, 7.2) 5)	-0.045	0.948
BMI (kg/m^2)	18.2 (16.7, 19.1)	17.75 (16.75, 18.9)	-3.975	0.837
Leukocytes (10^{12} /L)	6.72±1.36	5.92±1.26	2.91	0.005
Neutrophils (10^{12} /L)	3.40±0.64	2.87±0.82	3.41	<0.001
Hemoglobin (g/L)	137.88±12.78	137.7±12.64	0.070	0.945
Blood potassium (mmol/L)	3.78 (3.57,3.97)	3.78 (3.61,3.96)	-0.382	0.705
Preoperative waiting time (h)	2.4 (1.85,4.35)	36.5 (26.13, 42)	0.653	<0.001
Surgical time (h)	0.868±0.144	0.898±0.133	-1.027	0.307
Anesthesia time (h)	1.1(1,1.2)	1.2(1,1.25)	-0.099	0.069
Postoperative vomiting, n (%)			7.704	0.006
Not have	41 (95.3%)	34 (73.9%)		
There are	2 (4.7%)	12 (26.1%)		
Postoperative fever, n (%)			-0.748	0.524
not have	39 (90.7%)	38 (82.6%)		
≤38.5°C	4 (9.3%)	7 (15.2%)		
Postoperative pain, n (%)			0.155	0.926
pain-free	6 (14%)	6 (13%)		
mild pain	35 (81.4%)	37 (80.4%)		
moderate pain	2 (4.7%)	3 (6.5%)		
Postoperative			0.114	0.736

bleeding, n (%)				
not have	41 (95.3%)	42 (91.3%)		
there are	2 (4.7%)	4 (8.7%)		
Incision infections, n (%)			2.151	0.142
not have	43 (100%)	42 (91.3%)		
there are	0 (0%)	4 (8.7%)		
Postoperative hospitalization (h)	16.3 (6.16, 20.68)	62.16 (45.78, 75.30)	1.726	<0.001
Total hospitalization time (h)	21.5 (9.5, 24.25)	100 (73.25, 118.75)	2.435	<0.001
Total cost (dollars)	8556 (7900.1, 9451.7)	10120 (8964.5,1.1590)	1.993	<0.001
job satisfaction	1(1,1.2)	1.6 (1,1.8)	1.012	0.001

3.2 Screening of risk factors for delayed discharge in children with CH under day surgery

As the rate of delayed discharge in children with CH under day surgery was low in this study, and there were fewer children with delayed discharge of CH, all clinical characteristics, biochemical indicators, and imaging features exhibited varying degrees of covariance. Consequently, Lasso regression was initially performed on the raw data to complete the regularization process, with the presence or absence of delayed discharge used as the dependent variable. Lasso regression was then employed to first screen the risk factors for delayed discharge. In order to ensure the inclusion of independent variables, the coefficients will gradually be compressed. Ultimately, some of these coefficients will be compressed to zero, thus avoiding the overfitting of the model. The same 10-fold cross-validation procedure is employed to identify the most representative risk factors. As can be observed, the plot of the data at λ=0.006 (λ minimum) and λ=0.013 (1se minimum) reveals two straight lines. The identification and screening of seven non-zero coefficients characterizing the variables was conducted at λ.1se (λ=0.013). These coefficients were derived from the model and represent age, BMI, anesthesia time (H3), neutrophil count, blood potassium, waiting time for the surgery (H1), and hemoglobin. Please refer to Figure 1 for details.



Note: The left panel shows the process of screening risk parameters by 10-fold cross-validation in the Lasso regression model; the right panel shows the dynamic process of screening risk parameters in the Lasso regression model.

Figure 1: Lasso regression model for risk parameter screening

The seven risk parameters identified through Lasso regression were incorporated into a multifactorial logistic regression model for further analysis. The results of this model indicated that age (OR=0.922, 95% CI: 0.980-0.953), BMI (OR=1.138, 95% CI: 1.108-1.258), and neutrophil count (OR=0. The results demonstrated that age (OR=0.922, 95% CI: 0.980-0.953), BMI (OR=1.138, 95% CI: 1.108-1.258), neutrophil count (OR=0.994, 95% CI:0.991-0.997), and blood potassium (OR=1.007, 95% CI:0.998-1.016) were all independent risk factors for the occurrence of delayed discharge after daytime surgery for pediatric CH. Furthermore, the difference was statistically significant (P<0.05). Please refer to Table 2 for further details.

Table 2: Multifactorial analysis of risk factors for delayed discharge after day surgery in CH

Eigenvalue (math.)	**Total (N)**	**One-way analysis of variance**			**Multifactorial analysis**	
		OR (95% CI)	***P***		**OR (95% CI)**	***P***
(a person's) age	43	0.945 (0.923-0.967)	<0.001		0.922 (0.890-0.953)	<0.001
BMI	43	2.026 (1.509-2.543)	<0.001		1.138 (1.018-1.258)	0.035
Hemoglobin	43	0.887 (0.803-0.971)	0.024		0.046 (-4.909-5.001)	0.223
Neutrophil count	43	1.002 (1.001-1.004)	<0.001		0.997 (0.993-1.001)	0.013
Potassium	43	1.008 (1.003-1.012)	0.002		1.007 (0.998-1.016)	0.046
H3	43	1.007 (1.004-1.009)	<0.001		1.011 (1.000-1.022)	0.042
H1	43	0.658 (0.234-1.082)	0.053			

3.3 Construction of a predictive model for the risk of delayed discharge from day surgery in children with CH and visualization of nomogram plots.

Based on the results of the aforementioned Lasso regression as well as the multifactorial logistic regression combined analysis, five risk factors were identified, namely age, BMI, Anesthesia duration (H3), neutrophil count, and blood potassium were selected as the independent variables for the construction of a predictive model for the risk of delayed discharge after day surgery in children with CH, with delayed discharge as the dependent variable. A regression equation prediction model was constructed, as follows: logistic(P)=-54.665-1.095 age+2.158 BMI-2.118 neutrophil count+2.844 blood potassium+13.131 anesthesia time. Nomogram plots were constructed to facilitate visual representation of the model. For an illustration of this concept, please direct your attention to Figure 2. The nomogram plot model allows for the clear visualization of the relationship between each individual risk factor and its corresponding score. These scores are then accumulated to arrive at a final total score. The total score for the postoperative period of day surgery in children with CH can be used to estimate the probability of a delayed discharge event.

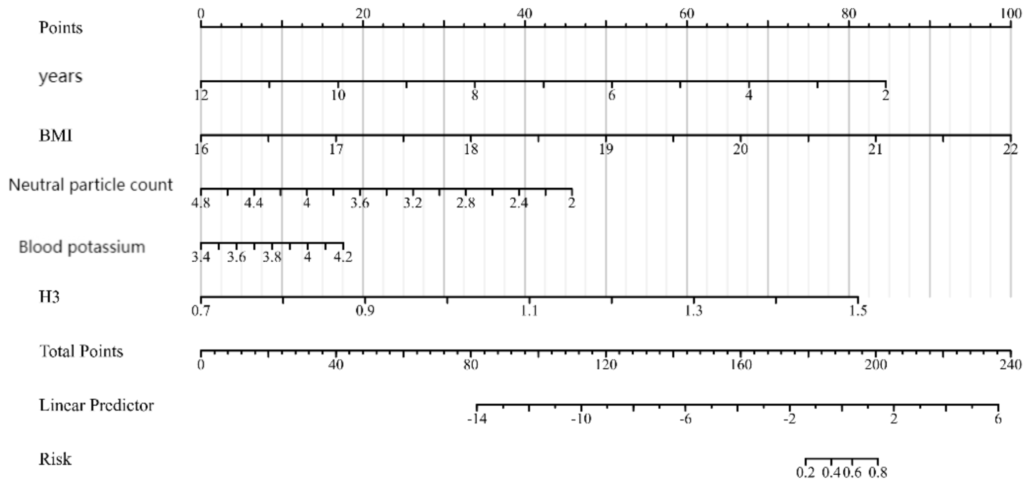


Figure 2: Nomogram of the predictive model for the risk of delayed discharge after day surgery in children with CH

3.4 Internal validation and evaluation of a predictive model for the risk of delayed discharge from day surgery for children with CH

Calibration: Through the analysis of results from 1,000 random samplings conducted via the Bootstrap method, an accurate internal prediction calibration curve can be obtained, as illustrated in Fig. 3. Following calibration, the curve in the figure is found to be almost perfectly consistent with the ideal curve, indicating that the model exhibits excellent prediction accuracy. Furthermore, the likelihood ratio test yielded a P-value of less than 0.05, suggesting that the model is reliable throughout the system. Finally, the C-index of this model was found to reach 0, indicating that it is highly accurate. The C-index value was 0.983 (95% CI: 0.952-1.014), indicating that the model exhibited a high degree of accuracy, even exceeding 0.9. Following a rigorous goodness-of-fit test, the P-value reached 0.8442, indicating that the discrepancy between the predicted and actual values was minimal, thereby substantiating the model's exceptional fitting ability.

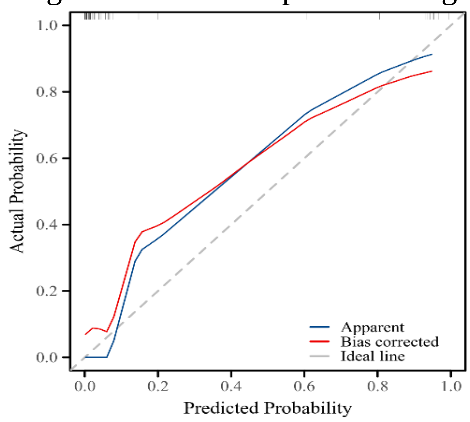


Figure 3: Calibration curves for the Nomogram model of the risk of delayed discharge after daytime surgery in children with CH

Differentiation: The study employed receiver operating characteristic (ROC) curve analysis to assess the predictive efficacy of the model. As illustrated in Figure 4, the area under the curve (AUC) for Union, which predicts the probability of five-joint involvement, was the highest among the evaluated variables, including age, body mass index (BMI), neutrophil count, potassium, and anesthesia time (H3). The AUC for Union was 0.977 (95% CI: 0.932-1.000), indicating a strong predictive capacity. Additionally, the sensitivity and specificity for Union were 94.57% and 93.75%, respectively. As indicated in Table 3, the predictive model demonstrates an excellent predictive efficacy with high accuracy.

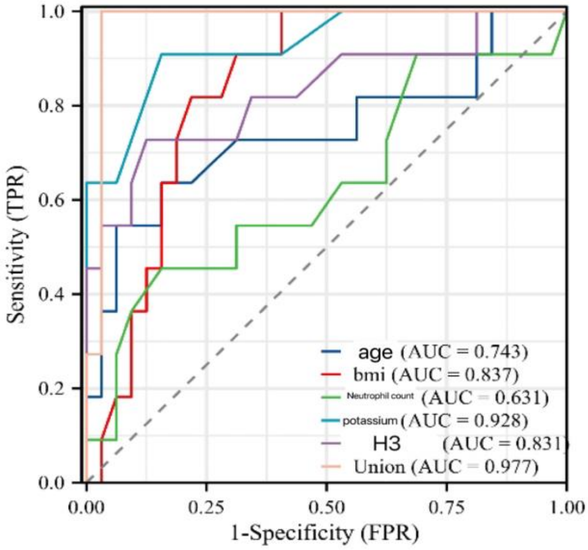


Figure 4: ROC curves for 5 risk predictors and joint prediction

Table 3: Diagnostic validity analysis of 5 risk predictors and joint prediction

norm	AUC	Sensitivity (%)	Specificity (%)	Accuracy (%)
(a person's) age	0.743	54.55	93.75	83.72
BMI	0.837	81.82	78.13	79.07
Neutrophil count	0.851	90.91	75	79.07
potassium	0.928	90.91	84.38	86.05
H3	0.831	72.73	87.5	83.72
Union	0.977	94.57	93.75	95.40

Clinical Applicability: The DCA curve was employed in this study to evaluate the model's clinical applicability. When the DCA curve's threshold probability is between 0 and 89%, the model predicts delayed discharge with a net benefit of >0. The utilization of this predictive model markedly enhances the child's treatment outcome, indicating its pivotal role in clinical practice. Figure 5 illustrates the aforementioned findings.

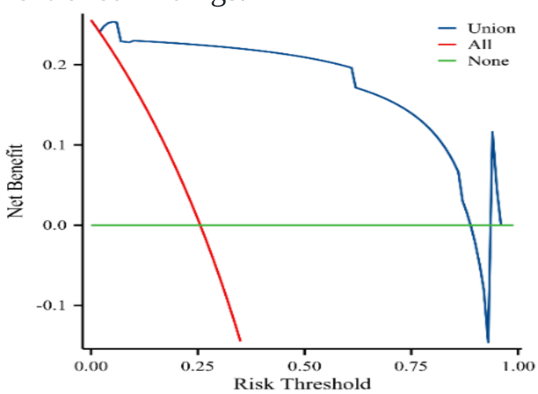


Figure 5: DCA curve for predictive modeling

4. Discussion

Syringomyelia is a prevalent condition among male children, with an increasing prevalence over time. With the relaxation of fertility policy, an increasing number of parents are expressing concern about the development of their children's reproductive organs and are becoming more aware of the potential risks associated with syringomyelia. Consequently, there has been a notable rise in the demand for treatment. However, currently, China's medical resources are limited, and large tertiary hospitals are experiencing numerous challenges. Consequently, identifying convenient and efficient treatment modalities has become a pivotal concern. Day surgery represents a novel treatment modality that has witnessed rapid development in both domestic and international contexts. It has garnered considerable recognition for its capacity to reduce patients' waiting time, enhance bed utilization, abbreviate hospitalization duration, and curtail the consumption of medical resources. Moreover, it has been shown to enhance patients' experience of treatment. In China, day surgery has been implemented across numerous medical specialties[9],and has been carried out in many disciplines and has mature experience, including urology surgery for syringomyelia[10]. However, there is a paucity of high-quality research in this field, particularly in the area of day surgery without drainage for the CH subtype[11].

In this study, we conducted a retrospective evaluation of the CH day surgery without drainage model and collected clinical data from 89 children. The results demonstrated that this model exhibits comparable efficacy and safety to the traditional urological specialist drainage hospitalization model, aligning with the findings of relevant reports from domestic and international sources. The results demonstrated that this model exhibited comparable efficacy and safety to the traditional urologic drainage hospitalization model, which is also consistent with the findings reported in domestic and international literature[12]. Additionally, this model demonstrated advantages in terms of hospitalization time and cost, aligning with the demand for high-quality healthcare. Postoperative vomiting was identified as a prevalent perioperative complication in children with CH, contributing to wound dehiscence, electrolyte imbalances, prolonged hospitalization, and elevated medical expenses[13]. The incidence of postoperative vomiting in the day surgery group was significantly lower than that in the urology group, which may be attributed to the less traumatic nature of day surgery and the implementation of the ERAS concept to minimize the utilization of opioids and the duration of fasting and abstinence from food and drink.

In accordance with the "delayed discharge" stipulation, day surgery must be concluded within a 24-hour period. However, in instances where patients are unable to complete day surgery within the specified timeframe for medical, social, or administrative reasons, this may result in a delayed discharge[14]. A delayed discharge may have a detrimental impact on the progress of day surgery, potentially resulting in significant complications[15]. In order to address the issue of delayed discharge in ambulatory surgery, it is essential to construct a risk model for delayed discharge. In this study, we developed a risk prediction model based on age, BMI, duration of anesthesia, neutrophil count, and blood potassium. This model was constructed in accordance with the relevant risk factors derived from large national medical centers[16-17]. The predictive validity of the model was high, stable, and reliable. The model demonstrated high predictive power, stability, and absence of overfitting. The nomogram effectively identified high-risk patients, providing a foundation for preoperative communication and personalized treatment. Patients who are young, have a high BMI, undergo prolonged anesthesia, have a low neutrophil count, and have high preoperative potassium levels may be at an increased risk of delayed discharge. Of these factors, preoperative potassium levels can be most readily adjusted, and aggressive preoperative adjustments may prevent postoperative hypokalemia and delayed discharge.

While this study yielded some findings, there are still some issues that require further investigation. Firstly, it is possible that there may be a degree of selection bias and information bias present due to the inherent limitations of medical records and the lengthy time span over which they were collected. Secondly, the study was conducted at a single center with a limited number of delayed discharge cases. Additionally, only internal validation was performed, lacking external validation. Furthermore, challenges exist in screening predictor variables. To construct more effective models, multicenter, large-sample, prospective clinical studies incorporating other predictive model characteristics and clinically guiding factors are needed. It is recommended that future research should include details of anesthesia medication, modality, and resuscitation, as these factors were not included in the present study. In conclusion, the no-drainage model of day surgery for pediatric syringomyelia has certain advantages, but further in-depth studies are required to fully elucidate its potential. Ongoing enhancements to this model and comprehensive investigations to address current limitations will facilitate the delivery of safer and more efficient healthcare for children, while also advancing the development of day surgery technology, particularly in the context of syringomyelia treatment in China.

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