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Original article

Development and validation of a nomogram for predicting self-propelled postpyloric placement of spiral nasoenteric tube in the critically ill: Mixed retrospective and prospective cohort study

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SUMMARY

Background & aims: Equipment-aided or experience-dependent methods for postpyloric nasoenteric tube placement are not so readily accessible in the critically ill setting. Self-propelled postpyloric placement of a spiral nasoenteric tube can serve as an alternative approach. However, the success rate of this method is relatively low despite using prokinetics. This study aims to develop a user-friendly nomogram incorporating clinical markers to individually predict the probability of successful postpyloric nasoenteric tube placement and facilitate intensivists with improved decision-making before tube insertion.

Methods: Patients consecutively recruited in the stage between May 2012 through December 2016 constituted the development cohort for retrospective analysis to internally test the nomogram, and patients in the stage between January 2017 through March 2018 constituted the validation cohort for prospective analysis to external validate the nomogram. A multivariate logistic regression analysis was firstly performed in the development cohort by a backward stepwise method to identify the best-fit model, from which a nomogram was obtained. The nomogram was validated in the independent external validation cohort concerning discrimination, calibration. A decision curve analysis was also performed to evaluate the net benefit of insertion decision with the nomogram.

Results: A total of 364 and 119 patients, 52.7% and 55.5% with successful postpyloric placement, were included in the development and validation cohort, respectively. Predictors contained in the prediction nomogram included primary diagnosis, APACHE II score, AGI grade. The derived model showed good discrimination, with an area under the receiver operating characteristic curve (AUROC) of 0.809 (95%CI, 0.765–0.853) and good calibration. Application of the nomogram in the validation cohort also gave good discrimination with an AUROC of 0.776 (95%CI, 0.694–0.859) and good calibration. The decision curve analysis of the nomogram provided better net benefit than the alternate options (insert-all or insert-none).

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Conclusions: A prediction nomogram that incorporates primary diagnosis, together with APACHE II score and AGI grade can be conveniently used to facilitate the pre-insertion individualized prediction of postpyloric nasoenteric tube placement in critically ill patients.

1. Introduction

Nutrition therapy forms an integral part of the comprehensive care for critically ill patients, and postpyloric feeding is highly recommended by guidelines [1–4] for those at high risk of aspiration or having shown intolerance to gastric feeding. Various techniques for postpyloric access are clinically available, ranging from manually approaches including blind bedside transpyloric tube placement to equipment-assisted techniques with the aid of endoscopic, fluoroscopic, electromagnetic, electrocardiographic or ultrasonic guidance [5,6]. However, those methods above are not so readily accessible in critically ill setting due to their heavy dependence on sophisticated devices or professional experience, thereby using a self-propelled spiral nasoenteric tube (NET) for postpyloric feeding can serve as an alternative approach [7–9]. Unfortunately, the overall success rate of self-propelled transpyloric migration of this spiral tube is relatively low (around 50%) despite using prokinetic agents [8–10]. Consequently, to establish a clinically available prediction model discriminating between a successful placement and a failed one can provide intensivists sensible decisions before inserting a self-propelled spiral NET.

Chen et al. [10] demonstrated the predictability of clinical markers, including pre-insertion use of prokinetics or not, and scoring systems, which were incorporated into decision trees for predicting successful postpyloric spiral NET placement in critically ill patients. However, the decision tree had turned inapplicable in the context of routine use of prokinetics before spiral NET insertion, which was strongly supported by a clinical trial [9]. Also, as a new measure for gastrointestinal function, the acute gastrointestinal injury (AGI) grade [11] had not been taken into account in the decision trees. Nomogram had gained gradual acceptance as a visualized, intuitive and appreciable tool in the critical care setting to facilitate practitioners' medical performance [12,13]. Therefore, this study aimed to develop a predictive nomogram incorporating clinical markers and scoring systems to individually predict the probability of successful postpyloric NET placement in critically ill patients.

2. Methods

2.1. Setting, participants, and data collection

This study was conducted in two stages, in intensive care units (ICUs) from fifteen tertiary hospitals across China. Data were collected and recorded into a database dating back to 2006 with AGI grading added since May 2012. In the first stage, all patients consecutively recruited from eleven centers between May 2012 through December 2016 were extracted. We included patients >18 years of age who underwent self-propelled spiral NET placement leveraging prokinetic drugs (including erythromycin, metoclopramide) as development cohort for retrospective analysis. Indications for self-propelled spiral NET placement were: requiring enteral nutrition, at high risk of aspiration or having shown intolerance to gastric feeding. Similarly, for the validation cohort all patients from seven centers who fulfilled the inclusion criteria were consecutively and prospectively collected in the second stage from January 2017 through March 2018. The study was approved by the research institutional review board of the participating centers, abiding by the standards of the Declaration of Helsinki. All cases were enrolled after obtaining informed consent. All tube insertion was conducted under the standard operating procedure, and tube tip position was ultimately confirmed radiologically.

Data concerning demographic characteristics, preexisting comorbidities, diagnosis, concomitant medication (sedation and analgesic therapy, inotrope and vasopressor therapy), mechanical ventilation, and APACHE II score, SOFA score, AGI grade were collected and documented at the time of tube insertion. Patients with incomplete data were excluded from the analysis. The outcome variable was successful postpyloric NET placement.

2.2. Sample size consideration

The sample size was calculated according to the rule of thumb recommended by Peduzzi et al. [14] and Harrell et al. [15], namely, events per variable being 10 or greater in the setting of multivariate regression model. We considered about 2–3 significant clinical factors and 2 to 3 scores in developing a model. This would have required a minimum sample size of 60 (6×10) participants who had events (successful postpyloric placement) to predict the outcome of successful postpyloric placement.

2.3. Statistical analysis

For continuous variables, the Shapiro–Wilk test was used to determine the normal distribution of the continuous variables. Wilcoxon-Mann-Whitney U-test was conducted for skewed distributions (presented as the median and interquartile range). Descriptive statistics for categorical variables were reported as frequency (percentage) and were compared using the Pearson χ^2 test or Fisher's exact test, as appropriate. Variables significant at the 0.1 level in univariate analyses were considered. Collinearity among all covariates was assessed using the Spearman correlation [16] and Belsley collinearity test [17].

To develop a predictive nomogram for the probability of success of postpyloric placement, a multivariate logistic regression analysis was firstly performed by a backward stepwise method to identify the reduced model in the development cohort. Covariates included age, diabetes, primary diagnosis, sedatives or analgesics, vasopressors, mechanical ventilation, APACHE II score, SOFA score, AGI grade. Estimate odds ratios (OR) and 95% confidence intervals (CI) were obtained. Discrimination was evaluated using the area under the curve (AUROC) derived from the conventional receiver operating characteristic (ROC) curves. AUROC as a measure of classification accuracy was further compared among those two models using the nonparametric approach of DeLong and Clarke-Pearson [18]. The accuracy, sensitivity, specificity, positive and negative predictive values (PPV and NPV, respectively) of the development and validation model were also calculated. Finally, a nomogram was obtained from the reduced model including identified predicting variables. The points of each predictor in the nomogram were first determined by drawing a vertical line from the factor to the point axis. Then, the sum of all the points from all predictors was used to generate the total points. By drawing a vertical line

Table 1
Clinical and demographic data for development and validation cohort.

Variables	Development Cohort				Validation Cohort			
	Total (n = 364)	Success (n = 192)	Failure (n = 172)	*P* value	Total (n = 119)	Success (n = 66)	Failure (n = 53)	*P* value
Age, y	60 (47–71)	59 (44–69)	63 (52–73)	0.020	62 (49–71)	61 (51–71)	62 (47–71)	0.077
Gender				0.828				0.032
Male	237 (65.1)	126 (65.6)	111 (64.5)		75 (63.0)	36 (54.5)	39 (73.6)	
Female	127 (34.9)	66 (34.4)	61 (35.5)		44 (37.0)	30 (45.5)	14 (26.4)	
Hypertension	72 (19.8)	36 (18.8)	36 (20.9)	0.602	41 (34.5)	21 (31.8)	20 (37.7)	0.500
Diabetes	25 (6.9)	19 (9.9)	6 (3.5)	0.016	15 (12.6)	7 (10.6)	8 (15.1)	0.463
Primary diagnosis				0.031				0.244
Neurologic	156 (42.9)	73 (38.0)	83 (48.3)		83 (69.7)	42 (63.6)	41 (77.4)	
Cardiovascular	51 (14.0)	25 (13.0)	30 (17.4)		9 (7.6)	7 (10.6)	2 (3.8)	
Respiratory	101 (27.7)	63 (32.8)	41 (23.8)		7 (5.9)	4 (6.1)	3 (5.7)	
Sepsis	11 (3.0)	6 (3.1)	6 (3.5)		6 (5.0)	3 (4.5)	3 (5.7)	
Multitrauma	21 (5.8)	15 (7.8)	6 (3.5)		5 (4.2)	5 (7.6)	0 (0.0)	
Others	24 (6.6)	10 (5.2)	6 (3.5)		9 (7.6)	5 (7.6)	4 (7.5)	
Sedatives or analgesics	103 (28.3)	41 (21.4)	62 (36.0)	0.002	32 (26.9)	12 (18.2)	20 (37.7)	0.017
Vasopressors	46 (12.6)	11 (5.7)	35 (20.3)	<0.001	23 (19.3)	8 (12.1)	15 (28.3)	0.026
Mechanical ventilation	228 (62.6)	106 (55.2)	122 (70.9)	0.002	76 (63.9)	40 (60.6)	36 (67.9)	0.409
APACHE II score	20 (16–25)	19 (15–23)	23 (18–27)	<0.001	20 (16–25)	17 (14–22)	23 (19–28)	<0.001
SOFA score	9 (8–11)	9 (7–10)	9 (8–12)	0.001	7 (6–9)	6 (5–8)	8 (6–9)	0.001
AGI grade				<0.001				0.006
0	2 (0.5)	2 (1.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	
I	221 (60.7)	152 (79.2)	69 (40.1)		86 (72.3)	54 (81.8)	32 (60.4)	
II	100 (27.5)	37 (19.3)	63 (36.6)		29 (23.5)	12 (18.2)	16 (30.2)	
IV	41 (11.3)	1 (0.5)	40 (23.3)		5 (4.2)	0 (0.0)	5 (9.4)	

APACHE II, Acute physiology and chronic health evaluation II; SOFA, Sequential organ failure assessment; AGI, Acute gastrointestinal injury; IQR, interquartile range. Data presented as median (IQR) or n (%).

from the total point axis to the risk of success of postpyloric placement axis, the estimated probability of success of postpyloric placement could be obtained.

Next, validation and calibration of the best-fit model and nomogram were performed using bootstrapping methods [19]. The bootstrap method was used with 1000 resamples, and the bootstrap-corrected AUROC and 95% CI were reported. The Hosmer–Lemeshow test [20] was used to assess the calibration plots of the nomogram. The validity of the nomogram model was verified in the independent external validation cohort concerning discrimination, calibration. Decision curve analysis was also performed to evaluate the net benefit of decision for postpyloric NET insertion with the nomogram at different threshold probabilities in the validation cohort. All tests were two-sided with an alpha level of 0.05.

The statistical analysis was carried out using the programs SAS software (SAS v9.4; SAS Institute, NC, USA) and R v3.3.3 (R Foundation for Statistical Computing, Vienna, Austria) using RStudio v1.0.136 (RStudio Inc, Boston, MA, USA).

3. Results

3.1. Cohort description

3.1.1. Development cohort

Of 374 patients recruited in the first stage from eleven participating centers, ten patients with incomplete data were excluded from the analysis. Thus, a total of 364 patients, 52.7% with successful postpyloric placement, were included in the development cohort (Table 1).

3.1.2. Validation cohort

Of 123 patients recruited in the second stage from seven participating centers, four patients with incomplete data were not included in the analysis. Then a total of 119 patients, 55.5% with successful postpyloric placement, were involved in the validation cohort (Table 1).

3.2. Development of the nomogram model

Variables including diabetes, sedatives or analgesics, vasopressors, mechanical ventilation were eliminated from multivariate logistic regression due to nonsignificance (P > 0.1). SOFA score and age were excluded due to collinearity with APACHE II score. Primary diagnosis, APACHE II score, and AGI grade were identified as the independent predictors in the logistic regression analysis (Table 2). The prediction model that incorporated the identified predictors was completed and presented as the nomogram (Fig. 2). Patients with respiratory diseases (odds ratio [OR], 3.47; 95% CI, 1.90–6.32; P, <0.001) or multitrauma (OR, 2.94; 95% CI, 0.97–8.87; P, 0.056) had higher probabilities of success. On the other side, the higher the APACHE II score (OR, 0.90; 95% CI, 0.86–0.87; P, <0.001) or AGI grade (OR, 0.16; 95% CI, 0.10–0.27; P, <0.001) was, the less likely the postpyloric placement was to be achieved. ROC analyses of predictors for the success of postpyloric placement in the development cohort was demonstrated in Fig. 1. Corresponding PPV and NPV with 95% CI (%) for development model were 63.4 (56.2–70.5) and 81.8 (76.3–87.2), respectively (Table 3).

3.3. Validation of the nomogram model

ROC analyses of predictors for the success of postpyloric placement in the validation cohort was demonstrated in Fig. 1. The AUROC (95%CI) for development and validation cohort were 0.809

Table 2
Multivariate logistic regression analysis of predictors for the success of postpyloric placement in the development cohort.

Influencing factors	OR (95% CI)	*P* value
Primary diagnosis		<0.001
Neurologic/Cardiovascular/Sepsis/Others	1.00 (referent)	
Respiratory	3.47 (1.90–6.32)	<0.001
Multitrauma	2.94 (0.97–8.87)	0.056
APACHE II score	0.90 (0.86–0.94)	<0.001
AGI grade	0.16 (0.10–0.27)	<0.001

OR, Odds ratio; CI, Confidence Interval.

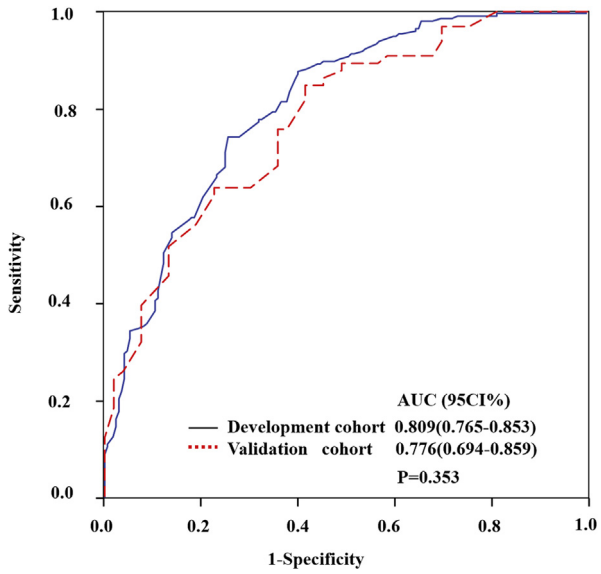

Fig. 1. Receiver operating characteristic curve analyses of predictors for the success of postpyloric placement in the development and validation cohort.

(0.765–0.853), 0.776 (0.694–0.859) without significant difference (DeLong test, P = 0.353). Corresponding PPV and NPV with 95% CI for validation model were 62.2 (49.2–75.3) and 75.8 (65.4–86.1), respectively (Table 3). Calibration plots for the nomogram in the development (Fig. 3A) and validation (Fig. 3B) cohort were generated. Both plots are slightly non-linear and agreed well in low predicted probabilities of success of postpyloric placement <50%, and the disagreement between the two plots slightly grows with the predicted probability of success of postpyloric placement≥50%.

3.4. Clinical use

The decision curve analysis for the nomogram is presented in Fig. 4. Threshold probability is the probability of a successful postpyloric NET placement from which an intensivist considers that it may insert a NET. The decision curve showed that if the threshold probability of a successful postpyloric NET placement was 5% or above, which explicitly covered the range of clinically reasonable threshold probabilities (probability of success greater than 50%), using the nomogram in the current study to predict successful insertion added more benefit than alternative strategy (insert-all or insert-none).

4. Discussion

This study demonstrated that primary diagnosis, APACHE II score, and AGI grade were independent predictors, and developed an user-friendly nomogram with clinical usefulness to predict the individual probability of successful postpyloric spiral tube placement in critically ill patients. To our knowledge, this study is the first attempt to establish a prognostic nomogram for postpyloric tube placement based on the clinical data of patients who underwent self-propelled spiral NET placement with the assistance of prokinetics.

In the present study, the primary diagnosis was defined as the most severe and resource-intensive condition which occasioned the ICU admission. This study showed that patients with primary diagnosis of respiratory or multitraumatic disease had high probabilities of access of postpyloric placement in contrast with those with neurological, cardiovascular, sepsis or the other primary diagnosis. This is not hard to understand. It was generally acknowledged that brain injury brought in a range of systemic physiological effects [21]. Specifically, gastrointestinal dysfunction

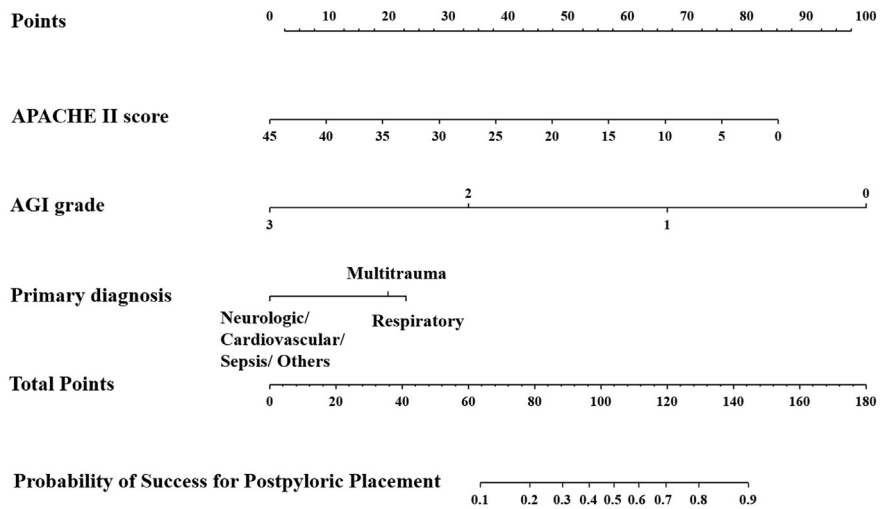

Fig. 2. Nomogram predicting the probability of success of postpyloric placement. To obtain the nomogram-predicted probability, locate patient values on each axis. Draw a vertical line to the point axis to determine how many points are attributed for each variable value. Sum the points for all variables. Locate the sum on the total point line to assess the individual probability of successful postpyloric placement.

Table 3
Detective characteristics of the development and validation cohort.

Cohort	AUC (95%CI)	Accuracy (95%CI)	Sensitivity (95%CI)	Specificity (95%CI)	NPV (95%CI, %)	PPV (95%CI, %)
Development	0.809 (0.765–0.853)	0.731 (0.685–0.776)	0.713 (0.654–0.773)	0.757 (0.687–0.827)	63.4 (56.2–70.5)	81.8 (76.3–87.2)
Validation	0.776 (0.694–0.859)	0.697 (0.614–0.780)	0.714 (0.608–0.820)	0.67.3 (0.542–0.805)	62.2 (49.2–75.3)	75.8 (65.4–86.1)

AUC, area under the receiver operating characteristic curve; CI, confidence interval; NPV, negative predictive value; PPV, positive predictive value.

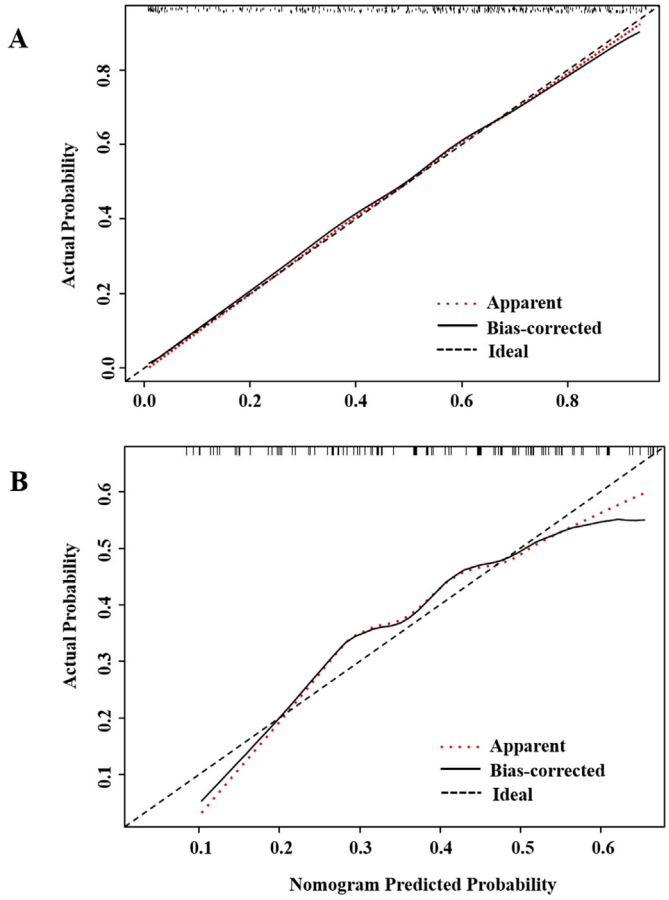

Fig. 3. Calibration plot for nomogram in the (A) development cohort and (B) validation cohort. The 45° dashed line represents ideal predictions, the plot illustrates the accuracy of the best-fit model ("Apparent") and the bootstrap model ("Bias-corrected") for predicting success of postpyloric placement≥50%. Locally weighted scatterplot smoothing was used to illustrate the relationships of the two models with the ideal line. Both plots are slightly non-linear and agree well in low predicted probabilities of success of postpyloric placement <50%, but the disagreement between the two plots grows with the predicted probability of success of postpyloric placement ≥50%. The 0.9 quantile absolute error of the predicted probability are 0.011 (development cohort) and 0.028 (validation cohort) respectively. The black dots illustrate the relationship between the predicted probability and observed probability of the scoring system for predicting success of postpyloric placement≥50% in the original data set.

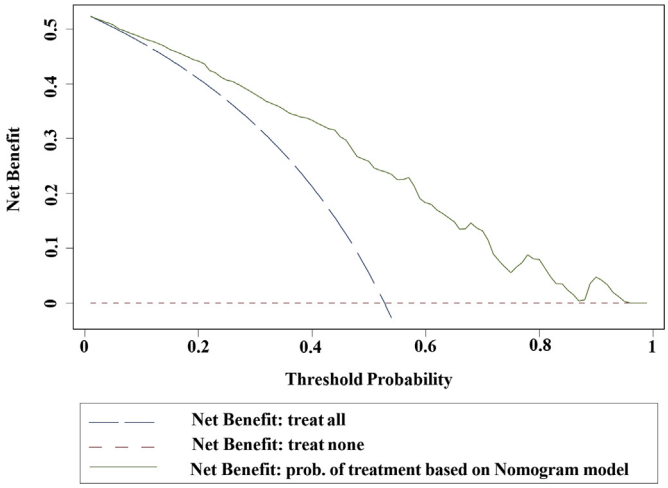

Fig. 4. Decision curve analysis of postpyloric tube placement in patients with the model nomogram. The y-axis measures the net benefit. The green line represents the model nomogram. The blue long-dashed line represents the assumption that all patients undertake postpyloric tube placement. Thin red dashed line represents the assumption that no postpyloric patient undertakes tube placement. The net benefit was calculated by subtracting the proportion of all patients who are false positive from the proportion who are true positive, weighting by the relative harm of forgoing treatment compared with the negative consequences of an unnecessary treatment. Threshold probability is the probability of successful postpyloric placement from which an intensivist considers that he decides a tube insertion. The decision curve showed that if the threshold probability of a successful postpyloric nasoenteric tube placement is 5% or above, which explicitly covers the range of clinically reasonable threshold probabilities (probability of success greater than 50%), using the nomogram in the current study to predict successful insertion adds more benefit than the insert-all scheme or the insert-none scheme. For example, if the personal threshold probability of a successful placement is 50% (ie, the intensivist would opt for placement if the patient's probability was 50%), then the net benefit is 0.258 when using the nomogram to make the decision of whether to undergo the placement, with added benefit than the insert-all scheme or the insert-none scheme.

was frequently observed in subjects with brain injury, including mucosal alterations, inflammation that could lead to increased gut permeability, motility abnormalities and ulceration [22,23]. Likewise, cardiovascular diseases such as chronic heart failure, involved in the pathogenesis of mucosal ischemia and ischemia-reperfusion injury resulting in gastrointestinal functional impairment. In addition, use of vasopressors in hypotensive patients acerbated the impaired bowel perfusion closely followed by the intestinal disorders. Sepsis induced multiple organ dysfunction syndrome including gastrointestinal dysfunction, through the mediation by a complex interplay between inflammation and endothelial and coagulation dysfunction incited by the infectious insult [24]. By contrast, even though mechanical ventilation may unfavorably affect the gastrointestinal tract, it could promptly restore the gastrointestinal function by reversing the hypoxia, which typically manifested in respiratory diseases and decreased tissue oxygenation and gastrointestinal blood flow. When it came to the multitrauma subgroup, one of the possibilities unable to be ruled out was that the relatively mild condition on admission helped retain the major gastrointestinal function and therefore contributed to the relatively higher success rate of postpyloric placement, if note the fact that most of the participating hospitals were not the local trauma centers.

Studies demonstrated that APACHE II score agreed well with the severity of diseases and could serve as a promising predictor for hospital outcome [25,26]. Consistently in our study, the APACHE II score accounted for a big weight in the prediction nomogram. SOFA score as another frequent scoring system reflecting disease severity, however, was eliminated in the logistic regression. That is attributed to the fact that SOFA shared a majority of common points-giving conditions with APACHE II, which resulted in collinearity between the two scoring systems [27]. Additionally, in the predicting model, we analyzed the AGI grade [11], a new grading scale in recent years used to evaluate the gastrointestinal condition. Studies [28,29] had demonstrated the AGI grading scheme was useful for identifying the severity of gastrointestinal dysfunction and could be used as a predictor of impaired outcomes. Therefore, AGI grade is conceivable to serve as a potential predictor for self-propelled postpyloric NET placement which depended highly on gastrointestinal motilities. Consistently, our study had established that AGI grade played an essential role in predicting the individual probability of successful spiral NET placement.

These discoveries in some way contradicted the study by Chen et al. [10], which focused on establishing decision trees for predicting successful postpyloric spiral tube placement in critically ill patients regardless whether administrated prokinetics or not. Unlike the previous study, the present study omitted the variable of prokinetics as a candidate predictor, given the fact that prokinetics

were validated as a strongly protective factor for successful postpyloric placement [9,10,30], and prokinetics had been routinely applied before spiral NET insertion if indicated. On this account, our study targeted those critically ill patients who underwent self-propelled spiral NET placement using prokinetics. Note that it was the primary diagnosis rather than vasopressor and sedatives or analgesics that was identified as one of the independent predictors. Patients with respiratory or multitraumatic disease had higher probabilities of successful postpyloric placement. It can be attributed to two speculations. One is that the adverse impact of vasopressors and sedatives or analgesics on gastric motility was lessened when prokinetics were administrated. Another is that patients with respiratory or multitrauma diseases had a lower chance of use of vasopressors, which led to decreased gastrointestinal flow and impaired motility.

In the evolution of decision support tools for critical care, bedside computerized as well as graphical decision-making tools including decision tree and nomogram have gained gradual acceptance for improved diagnosis, monitoring, risk prediction, treatment and outcome [10,12,13,31]. However, although decision trees are simple to comprehend, they are often unstable and relatively inaccurate, especially for data including categorical variables with different number of levels [32]. Nomograms flourished in many different contexts because they allowed quick and accurate computations free of calculators. The prediction nomogram was derived based on clinically available factors and offered a seeable and easy-to-use ruler for predicted probability. Results from a nomogram are generated very quickly and reliably by merely drawing one or more lines without substituting numbers into equations for obtaining results. This study incorporated the identified predictors in logistic regression into a prediction model, and ultimately depicted a clinically-validated practicable nomogram based on the model.

The foremost point for the use of the nomogram is to interpret individual successful postpyloric NET placement. However, the prediction performance of discrimination and calibration, could not fully represent the clinical usefulness on a particular level of discrimination or degree of calibration. Therefore, to validate the clinical practicality of the nomogram, we assessed whether the nomogram-assisted decisions would improve the success rate of postpyloric placement. For this purpose, we employed decision curve analysis in this study to validate the nomogram in a multicenter prospective cohort. This novel method yielded insight into clinical consequences on the basis of threshold probability, from which the net benefit could be derived. The decision curve showed that if the threshold probability of a successful postpyloric NET placement was 5% or above, which explicitly covered the range of clinically reasonable threshold probabilities (probability of success greater than 50%), using the nomogram in the current study to predict successful insertion added more benefit than alternative strategy (insert-all or insert-none). Obviously, the nomogram will not only substantially facilitate intensivists an advisable decision before tube insertion but also clearly provide patients benefit from a successful tube insertion or against a failed one. A further study regarding cost-effectiveness analysis of competing NET placement strategies aimed at achieving safe and effective enteral feeding, either nomogram-guided or not, may be needed before widespread clinical application.

Our study contained the following strengths. First, using a two-stage design, we showed consistent results in both the development and validation cohorts. Also, the study participants were recruited from fifteen centers, representing patients requiring postpyloric placement in various critically ill settings across China. The present study also had certain limitations. The number of patients was relatively small for developing a prediction model though subjects more than the calculated sample size were retrieved. Thus, it is possible that the predictive accuracy of the model was under- or over-estimated in this study. Also, this study is limited by the nature of overestimating the predictive performance inherent to retrospective studies [33], although external validation in a prospective cohort has minimized the overfitting effect.

5. Conclusions

A prediction nomogram that incorporates primary diagnosis, together with APACHE II score and AGI grade can be conveniently used to facilitate the pre-insertion individualized prediction of postpyloric NET placement in critically ill patients.

Statement of authorship

LHH, ZQN, YCZ, and CBC contributed the conception and design of the study. All authors contributed to the acquisition of data, analysis and interpretation of data. All authors drafted the article and revised it critically for important intellectual content, and approved the final manuscript to be submitted.

Conflict of interest

The authors declare that they have no conflict of interest.

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List of abbreviations

AGI	Acute Gastrointestinal Injury
APACHE II	Acute Physiology and Chronic Health Evaluation II
AUROC	Area under the receiver operating characteristic curve
CI	Confidence interval
ICU	Intensive care unit
IQR	Interquartile range
NET	Nasoenteric Tube
NPV	Negative Predictive Value
SOFA	Sequential Organ Failure Assessment Score
OR	Odds Ratio
P	*P* value
PPV	Positive Predictive Value
ROC	Receiver Operating Characteristic

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