

Clinical Prediction Score for Post-Intubation Hypotension Among Patients with Suspected Sepsis: A Retrospective Cohort Study

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Abstract: **Introduction:** Post-intubation hypotension (PIH) is a clinically important complication of emergency airway management and may be particularly relevant in patients with sepsis because of their limited hemodynamic reserve. This study aimed to develop and internally validate a clinical prediction model for PIH and derive a simplified bedside score. **Methods:** We conducted a retrospective cohort study of patients aged ≥ 15 years with suspected or confirmed sepsis who underwent emergency endotracheal intubation in the emergency department of Ramathibodi Hospital between January 2013 and December 2023. PIH was defined as systolic blood pressure < 90 mmHg within 30 minutes after intubation. Candidate predictors were evaluated using logistic regression, and model reduction was guided by clinical relevance and model fit. Internal validation was performed using 1,000 bootstrap resamples. A simplified score was derived from the final model by categorizing continuous predictors and assigning points based on their regression coefficients. **Results:** Among 372 patients, 66 (17.7%) developed PIH. The final model included age, pre-intubation systolic blood pressure (SBP), non-rapid sequence intubation (non-RSI), and etomidate use. Increasing age (adjusted odds ratio [aOR]: 1.043 per year; 95% CI: 1.017–1.070) and non-RSI (aOR: 2.50; 95% CI: 1.40–4.47) were associated with higher odds of PIH, whereas higher pre-intubation SBP (aOR: 0.986 per mmHg; 95% CI: 0.977–0.996) and etomidate use (aOR: 0.46; 95% CI: 0.25–0.84) were associated with lower odds. The model had an apparent area under the receiver operating characteristic curve (AUROC) of 0.727 and an optimism-corrected AUROC of 0.711. The simplified 4-point score assigned one point each for age ≥ 75 years, SBP < 110 mmHg, non-RSI, and absence of etomidate use. PIH incidence increased from 7.7% at a score of 0 to 63.6% at a score of 4. The simplified score had an AUROC of 0.708 (bootstrap 95% CI: 0.641–0.775), which was not statistically different from that of the continuous model ($p=0.241$). **Conclusion:** A four-variable peri-intubation model showed moderate discrimination for PIH in patients with suspected sepsis undergoing emergency intubation. The simplified bedside score may help identify patients who require closer hemodynamic monitoring and preparation during airway management. External validation is needed before routine clinical use.

Keywords: Intubation; Intratracheal; Sepsis; Hypotension; Emergency Service; Hospital; Risk Assessment

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1. Introduction

Sepsis is a life-threatening condition characterized by organ dysfunction resulting from a dysregulated host response to infection and remains a major cause of morbidity and mortality worldwide. Patients with sepsis frequently develop respiratory failure, altered mental status, or other conditions requiring emergency endotracheal intubation (1, 2). Although tracheal intubation is often life-saving, it may be complicated by peri-intubation adverse events, particularly post-intubation hypotension (PIH). Previous emergency airway studies have shown that PIH is common and is associated with adverse clinical outcomes, including increased mortality and prolonged hospitalization (3-5).

Patients with sepsis may be especially susceptible to PIH because systemic vasodilation, increased vascular permeability, relative hypovolemia, myocardial dysfunction, and reduced

cardiovascular reserve may impair their ability to tolerate induction and positive-pressure ventilation (1, 2). Sedative administration and the transition from spontaneous to positive-pressure ventilation may further reduce venous return and systemic vascular resistance, leading to abrupt hemodynamic deterioration. Cardiovascular instability during emergency airway management is common in critically ill patients and has been associated with adverse outcomes (6, 7).

Several factors have been associated with PIH, including lower pre-intubation blood pressure, older age, shock index, illness severity, vasopressor requirement, and peri-intubation medication or airway-management characteristics (4-8). Prediction models have also been developed in heterogeneous critically ill populations. In a multicenter prospective study, Smischney et al. developed a PIH prediction model incorporating age, systolic blood pressure, sepsis, vasopressor use, and etomidate, with C-statistics ranging from approximately 0.71 to 0.75 (7).

However, models developed in broad critically ill populations may not fully capture the hemodynamic vulnerability of patients with sepsis undergoing emergency intubation. Evidence specific to this population remains limited. Tangkulpanich et

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al. examined patients with suspected sepsis undergoing emergency intubation and identified older age and elevated lactate as factors associated with PIH (9). Yet, individual risk factors alone do not provide a practical means of integrating multiple peri-intubation characteristics into an individualized risk estimate.

A simple bedside prediction tool tailored to patients with suspected sepsis could help identify those at increased risk of PIH and support closer hemodynamic monitoring and preparation during emergency airway management. Therefore, this study aimed to develop and internally validate a clinical prediction model for PIH among patients with suspected sepsis undergoing emergency endotracheal intubation and to derive a simplified bedside risk score from the final model.

2. Methods

2.1. Study design and setting

This retrospective cohort study was conducted in the emergency department of the Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand. Electronic medical records of patients with suspected or confirmed sepsis who underwent emergency endotracheal intubation in the emergency department between January 2013 and December 2023 were reviewed. Candidate predictors were evaluated using logistic regression, and model reduction was guided by clinical relevance and model fit. Internal validation was performed using 1,000 bootstrap resamples. A simplified score was derived from the final model by categorizing continuous predictors and assigning points based on their regression coefficients.

This study was approved by the Human Research Ethics Committee, Faculty of Medicine Ramathibodi Hospital, Mahidol University (COA No. MURA2024/872; approval date: December 4, 2024). The study was conducted in accordance with the Declaration of Helsinki and relevant institutional and international ethical guidelines. All directly identifiable patient information was removed from the analytical dataset and replaced with unique study identifiers to maintain confidentiality.

2.2. Participants

Patients were eligible if they were aged 15 years or older, presented to the emergency department with suspected or confirmed sepsis, and underwent endotracheal intubation in the emergency department. Patients were excluded if they had been intubated before arrival, had pre-intubation hypotension defined as systolic blood pressure (SBP) <90 mmHg, experienced cardiac arrest before intubation, or had insufficient medical-record data for the required clinical variables.

To reduce potential selection bias, all eligible patients meeting the predefined inclusion and exclusion criteria during the study period were considered for inclusion.

2.3. Data collection

Clinical data were retrospectively extracted from the hospital electronic medical record system. Variables included demographic characteristics, comorbidities, pre- and post-intubation vital signs, laboratory measurements, and peri-intubation management characteristics.

Candidate predictors evaluated in the present analysis included age, sex, pre-intubation SBP, heart rate, bicarbonate,

chronic kidney disease, heart disease, intravenous fluid administration before intubation, non-rapid sequence intubation (non-RSI), and etomidate use. Serum lactate was also evaluated; however, because lactate measurements were unavailable in a substantial proportion of patients, lactate was examined primarily in sensitivity analyses. Candidate predictors were selected based on clinical relevance and availability during the peri-intubation period.

2.4. Outcome measures

The primary outcome was post-intubation hypotension (PIH) occurring within 30 minutes after emergency endotracheal intubation. PIH was defined as a systolic blood pressure <90 mmHg at any time during this period. As this was a retrospective cohort study, outcome ascertainment was based entirely on blood pressure measurements routinely recorded in the electronic medical record during the fixed 30-minute post-intubation observation window. No active clinical follow-up beyond this window was performed. For prediction-model development, PIH was treated as a binary outcome.

2.5. Statistical analysis

Based on a previous study reporting an incidence of post-intubation hypotension of approximately 30% among patients with sepsis, the required sample size was calculated with an alpha of 0.05 and a statistical power of 0.80. The estimated sample size was approximately 340 patients.

All statistical analyses were performed using Stata version 18 (StataCorp LLC, College Station, TX, USA). Continuous variables were summarized as mean and standard deviation or median and interquartile range, as appropriate, and categorical variables as frequencies and percentages. Baseline characteristics were compared between patients with and without PIH using appropriate parametric or non-parametric tests for continuous variables and the chi-square or Fisher's exact test for categorical variables. All statistical tests were two-sided, with $p < 0.05$ considered statistically significant.

Predictor and outcome definitions were applied consistently across the cohort. Bootstrap internal validation was used to estimate model optimism and potential overfitting.

Univariable logistic regression was initially performed to assess the association between each candidate predictor and PIH. Continuous predictors were preferentially retained in their original form to minimize information loss. The functional forms of age and pre-intubation SBP were evaluated by comparing linear models with restricted cubic spline and clinically interpretable categorical specifications, using the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). Collinearity among candidate predictors was assessed using correlation analyses and cross-tabulation as appropriate.

A multivariable logistic regression model was then fitted using the candidate predictors. Model reduction was guided by clinical relevance, statistical contribution, likelihood ratio testing, AIC, and BIC, with the aim of obtaining a parsimonious predictive model. The final continuous model included age, pre-intubation SBP, non-RSI, and etomidate use. Associations were expressed as adjusted odds ratios (aORs) with 95% confidence intervals (CIs).

Model discrimination was assessed using the area under the receiver operating characteristic curve (AUROC). Calibration

was assessed using the calibration slope and calibration intercept together with graphical comparison of observed and predicted probabilities.

Internal validation of the final continuous model was performed using 1,000 bootstrap resamples. Bootstrap optimism in the AUROC was estimated and subtracted from the apparent AUROC to obtain an optimism-corrected estimate. Bootstrap estimates of the calibration slope and calibration intercept were also obtained to assess model overfitting and systematic miscalibration.

Because serum lactate was missing in 117 of 372 patients (31.5%), lactate was not included in the primary prediction model. As a sensitivity analysis, missing lactate values were handled using multiple imputation by chained equations with predictive mean matching. Forty imputed datasets were generated, and multivariable logistic regression, incorporating lactate and the predictors included in the final model, was performed using Rubin's rules. A complete-case analysis among patients with available lactate values was also conducted. No prespecified subgroup analyses or interaction analyses were performed.

To develop a simplified bedside score, clinically interpretable thresholds for age and SBP were evaluated after the continuous model was developed. Candidate thresholds were compared using model fit indices, with clinical interpretability in mind. Age ≥ 75 years and pre-intubation SBP < 110 mmHg were selected for the categorical score model. The categorical multivariable model, therefore, included age ≥ 75 years, SBP < 110 mmHg, non-RSI, and absence of etomidate use. Because the corresponding regression coefficients were of similar magnitude, one point was assigned to each predictor, yielding a total score ranging from 0 to 4.

The discrimination of the simplified score was evaluated using AUROC, with a 95% CI estimated using 1,000 bootstrap resamples. Observed PIH rates were calculated for each score level and were compared with model-predicted probabilities. Sensitivity, specificity, positive predictive value, negative predictive value, and positive and negative likelihood ratios were calculated for each score threshold. The AUROC of the simplified score was also compared with that of the final continuous model.

3. Results

3.1. Baseline characteristics of studied cases

A total of 372 patients with suspected or confirmed sepsis who underwent emergency endotracheal intubation were included in the final analysis (Figure 1). Post-intubation hypotension occurred in 66 (17.7%) patients, whereas 306 (82.3%) patients did not develop PIH. Baseline demographic, physiological, laboratory, and peri-intubation characteristics according to PIH status are presented in Table 1. Among these patients, the mean age was 74.9 ± 14.0 years, and 173 (46.5%) were male. The most common comorbidities were hypertension (74.5%) and diabetes mellitus (47.3%), followed by heart disease (39.2%) and chronic kidney disease (33.9%). The mean pre-intubation systolic blood pressure was 129.2 ± 32.1 mmHg, and the mean shock index was 0.88 ± 0.32 . Vasopressor use before intubation was recorded in 53 patients (14.2%). Non-RSI was performed in 142 patients (38.2%), and etomidate was used as the induction agent in 284 patients (76.3%).

3.2. Univariable logistic regression analysis

In univariable logistic regression analysis, increasing age was associated with higher odds of PIH (OR: 1.03 per year; $p=0.013$), whereas higher pre-intubation systolic blood pressure was associated with lower odds of PIH (OR: 0.985 per mmHg; $p=0.001$). Intravenous fluid administration before intubation (OR: 1.85; $p=0.037$), non-rapid sequence intubation (non-RSI) (OR: 2.44; $p=0.001$), and vasopressor administration before intubation (OR: 2.07; $p=0.030$) were associated with increased odds of PIH. Etomidate use was associated with lower odds of PIH (OR: 0.36; $p<0.001$). Sex ($p=0.530$), heart rate ($p=0.591$), bicarbonate level ($p=0.642$), chronic kidney disease ($p=0.637$), and heart disease ($p=0.760$) were not significantly associated with PIH.

3.3. Development and internal validation of the prediction model

The initial multivariable model included age, pre-intubation SBP, sex, bicarbonate, chronic kidney disease, heart disease, intravenous fluid administration before intubation, non-RSI, and etomidate use. Following assessment of model fit and parsimony, the final model retained four predictors: age, pre-intubation SBP, non-RSI, and etomidate use. Increasing age was independently associated with higher odds of PIH (aOR: 1.043 per year; 95% CI: 1.017–1.070; $p=0.001$), while higher pre-intubation SBP was associated with lower odds (aOR: 0.986 per mmHg; 95% CI: 0.977–0.996; $p=0.004$). Non-RSI was associated with approximately 2.5-fold higher odds of PIH (aOR: 2.50; 95% CI: 1.40–4.47; $p=0.002$), whereas etomidate use was associated with lower odds (aOR: 0.46; 95% CI: 0.25–0.84; $p=0.012$).

The final continuous model had an apparent AUROC of 0.727 (Figure 2A). Bootstrap internal validation using 1,000 resamples yielded a mean optimism of 0.017, resulting in an optimism-corrected AUROC of 0.711. Calibration is shown in Figure 2B; the mean bootstrap calibration slope was 0.929 and the calibration intercept was 0.009.

Serum lactate was available in 255 of 372 patients, with 117 patients (31.5%) having missing values. In the multiple-imputation analysis, lactate was not independently associated with PIH after adjustment for the predictors in the final model (aOR 1.05; 95% CI: 0.96–1.16; $p=0.252$). The complete-case analysis yielded a similar result (aOR 1.07; 95% CI: 0.97–1.18; $p=0.186$). Lactate was therefore not included in the simplified score.

3.4. Derivation and performance of the simplified PIH score

For bedside simplification, continuous age and SBP were converted to clinically interpretable categories. Age ≥ 75 years and pre-intubation SBP < 110 mmHg were selected for the categorical model. Age ≥ 75 years (aOR: 2.90; 95% CI: 1.52–5.51; $p=0.001$), SBP < 110 mmHg (aOR: 2.18; 95% CI: 1.20–3.97; $p=0.011$), non-RSI (aOR: 2.35; 95% CI: 1.32–4.18; $p=0.004$), and absence of etomidate use (aOR: 2.39; 95% CI: 1.31–4.35; $p=0.004$) were associated with PIH in the categorical model (Table 2). Because the corresponding regression coefficients were similar in magnitude ($\beta=1.064, 0.780, 0.854$, and 0.871 , respectively), one point was assigned to each predictor, yielding a simplified score ranging from 0 to 4 points. The observed incidence of PIH increased with increasing score, from 7.7% at a score of 0 to 8.9%, 21.4%, 40.5%, and 63.6% at scores of 1, 2, 3, and 4, respectively.

The simplified score demonstrated an AUROC of 0.708 (bootstrap 95% CI: 0.641–0.775). Its discriminatory performance was not statistically different from that of the final continuous model (AUROC 0.727 vs 0.708; $p=0.241$; Figure 2).

Diagnostic performance across score thresholds is presented in Table 3. At a threshold of ≥ 2 points, the score demonstrated a sensitivity of 74.2%, specificity of 59.2%, positive predictive value of 28.2%, negative predictive value of 91.4%, positive likelihood ratio of 1.82, and negative likelihood ratio of 0.44. At a threshold of ≥ 3 points, sensitivity decreased to 33.3%, whereas specificity increased to 91.5%, with a positive likelihood ratio of 3.92.

4. Discussion

In this retrospective cohort of patients with suspected or confirmed sepsis undergoing emergency endotracheal intubation, PIH occurred in 17.7%. The final model included age, pre-intubation SBP, non-RSI, and etomidate use and achieved an apparent AUROC of 0.727, which decreased only modestly to 0.711 after bootstrap correction for optimism. The simplified four-point score had an AUROC of 0.708, with PIH incidence increasing with higher scores.

PIH is an important complication of emergency airway management. Previous studies have reported substantial rates of hypotension after emergency intubation, although the incidence varies according to patient population, setting, and outcome definition (3–7). Heffner et al. demonstrated that PIH was associated with increased in-hospital mortality, while studies in critically ill populations have similarly linked peri-intubation hemodynamic deterioration with adverse outcomes (4–6). In the international INTUBE cohort, peri-intubation cardiovascular instability or collapse was common and independently associated with worse outcomes, emphasizing the importance of early recognition of patients at increased hemodynamic risk (6).

Age and pre-intubation SBP were the two baseline physiological predictors retained in the final model. This is consistent with previous studies in critically ill patients and in patients with suspected sepsis. Smischney et al. included both age and blood pressure in their multicenter PIH prediction model, while Tangkulpanich et al. identified advanced age as a risk factor in suspected sepsis (7, 9). Shock index, which incorporates both heart rate and SBP, has also been linked to PIH (8). Together, these observations suggest that limited cardiovascular reserve before induction is an important determinant of hemodynamic tolerance to intubation. In sepsis, vasodilation, relative hypovolemia, vascular leakage, and myocardial dysfunction may further reduce this reserve (1, 2).

Non-RSI was independently associated with higher odds of PIH. This finding should be interpreted cautiously because airway strategy is influenced by clinical circumstances, including urgency, neurological status, illness severity, airway difficulty, and clinician judgment. The observed association may therefore be influenced by confounding by indication, with non-RSI representing a marker of patient condition or airway-management context rather than a direct causal determinant of PIH. Previous studies have similarly suggested that peri-intubation technique and procedural characteristics may contribute to hemodynamic risk (4–9). Thus, the association with non-RSI should be viewed as a risk marker rather than evidence that RSI is universally preferable in patients with sepsis.

Etomidate use was associated with lower odds of PIH, and absence of etomidate use was therefore incorporated into the simplified score. Etomidate has also been included in previous PIH prediction research (7). Randomized studies comparing etomidate with ketamine have reported differences in peri-intubation cardiovascular instability, including a lower incidence of cardiovascular collapse with etomidate in a recent large trial, although mortality did not significantly differ between agents (10, 11). Because induction-agent choice was not randomized in our cohort, the observed association may partly reflect differences in baseline hemodynamics, illness severity, or clinician preference. This association should not be interpreted as evidence of a causal protective effect of etomidate.

The simplified score was designed to enhance bedside usability. Age ≥ 75 years, SBP < 110 mmHg, non-RSI, and absence of etomidate use were each assigned 1 point because their regression coefficients were of similar magnitude. PIH incidence increased from 7.7% among patients with a score of 0 to 63.6% among those with a score of 4. At a threshold of ≥ 2 points, the score demonstrated a sensitivity of 74.2% and a negative predictive value of 91.4%, whereas a threshold of ≥ 3 points increased specificity to 91.5%. These findings suggest that the score may assist clinicians in recognizing patients who warrant greater peri-intubation hemodynamic preparedness. However, these thresholds were derived from the development cohort and should be considered exploratory until independently validated. Intravenous fluid administration before intubation was associated with higher odds of PIH in univariable analysis, which may appear counterintuitive. This finding may reflect confounding by indication, as fluids may have been administered more often to patients with greater hemodynamic vulnerability. This interpretation is supported by the higher proportion of pre-intubation vasopressor use among patients who developed PIH (Table 1), although residual confounding cannot be excluded. The variable was included in the initial multivariable model but was not retained in the final model after model reduction. Identifying patients at elevated risk does not necessarily imply that a single prophylactic intervention will prevent PIH. Randomized trials of routine intravenous fluid administration before intubation have not demonstrated consistent reductions in peri-intubation cardiovascular collapse (12, 13). Hemodynamic optimization may therefore need to be tailored to the underlying physiology rather than applied uniformly. Our observational data cannot determine whether fluid administration itself influences the risk of PIH.

The proposed score may therefore be most useful for increasing vigilance, ensuring readiness for hemodynamic support, and prompting closer blood pressure monitoring, rather than mandating a specific fluid, vasopressor, airway technique, or induction agent strategy.

The final continuous model demonstrated limited optimism after bootstrap internal validation, with an optimism-corrected AUROC of 0.711, a calibration slope of 0.929, and a calibration intercept of 0.009. The simplified score retained discrimination close to that of the continuous model. The score may assist in identifying patients who warrant heightened hemodynamic monitoring and peri-intubation preparedness. Consistent with contemporary recommendations for prediction model evaluation (14), external validation in an independent, preferably multicenter cohort with different patient populations and airway management practices is an essential next step. Until such validation has been completed, the score should not be used as

a standalone tool to guide clinical decision-making.

Serum lactate was not incorporated into the final score. Tangkulpanich et al. previously identified elevated lactate as a factor associated with PIH among patients with suspected sepsis (9). In the present study, however, lactate was not independently associated with PIH in either multiple-imputation or complete-case sensitivity analyses, and measurements were unavailable in 31.5% of patients. Differences between studies may reflect variation in case mix, timing of lactate measurement, illness severity, or adjustment for other hemodynamic variables. Although lactate remains clinically relevant in sepsis assessment, it should be interpreted in the context of the overall clinical picture (2).

Importantly, this study evaluated the predictive performance of the score rather than its clinical impact. Whether use of the score changes clinician behavior, improves peri-intubation preparation, or reduces PIH or other patient-important outcomes remains unknown and should be evaluated prospectively after external validation.

4.1. Limitations

This study has several limitations. First, its retrospective, single-center design may introduce selection bias, information bias, residual confounding, and misclassification, and may limit generalizability to other emergency departments and healthcare systems. Second, the number of PIH events was relatively modest ($n=66$) in relation to the number of candidate predictors considered during model development, which may have increased the risk of model instability and overfitting. Although bootstrap internal validation was used to estimate optimism, some uncertainty in model performance remains. Third, the age and SBP thresholds used for score simplification were derived from the present dataset and may not represent optimal thresholds in other populations. Fourth, non-RSI and etomidate use are treatment-related variables that may reflect clinician decision-making and patient severity, resulting in potential confounding by indication. Their inclusion also means that the score is most applicable when the peri-intubation strategy and induction-agent plan are already known, rather than as a purely baseline pre-intubation prediction tool. This study spanned 2013–2023, a period during which sepsis management and emergency airway practices may have evolved, including changes in resuscitation strategies, airway techniques, and induction-agent selection. Such secular trends could mean that the observed associations of non-RSI and etomidate use with PIH partly reflect changes in clinical practice and case mix over time rather than stable effects. This should be considered when interpreting the estimates across the 10-year study period. Fifth, serum lactate was unavailable in 117 of 372 patients (31.5%). Although multiple-imputation and complete-case analyses yielded similar findings, this degree of missingness introduces uncertainty regarding the association between lactate and PIH, and a clinically relevant association cannot be completely excluded. The direction and magnitude of these potential biases are difficult to quantify. Confounding by indication could either exaggerate or attenuate the observed associations with non-RSI and etomidate use, depending on the relationship between treatment selection, patient severity, and clinician judgment. Missing lactate data may also have biased the estimated association if the likelihood of lactate measurement was related to illness severity or hemodynamic instability. In addition, residual confounding

arising from temporal changes in clinical practice may have influenced the observed effect estimates. Finally, the model and simplified score have undergone internal validation only. External validation, preferably in a larger multicenter cohort with different patient and airway-management characteristics, is required before routine clinical implementation.

5. Conclusion

In patients with suspected sepsis undergoing emergency endotracheal intubation, a parsimonious peri-intubation prediction model incorporating age, pre-intubation SBP, non-RSI, and etomidate use demonstrated moderate discrimination for PIH. The derived four-point bedside score showed an increasing incidence of PIH with higher scores while retaining similar discrimination to the continuous model. The score may assist in identifying patients who warrant heightened hemodynamic monitoring and peri-intubation preparedness; however, external validation is required before routine clinical implementation.

6. Declarations

6.1. Acknowledgments

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6.2. Conflict of interests

The authors declare that they have no competing interests.

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6.4. Authors' contributions

PN conceived and supervised the study, contributed to the study design, performed and interpreted the statistical analyses, and drafted and revised the manuscript. WT and CA contributed to the study design, clinical interpretation, and critical revision of the manuscript. KP, NJ, and SK contributed to data collection, data management, and manuscript preparation. All authors reviewed and approved the final manuscript.

6.5. Ethical statement

This study was approved by the Human Research Ethics Committee, Faculty of Medicine Ramathibodi Hospital, Mahidol University (COA No. MURA2024/872; approval date: December 4, 2024). The study was conducted in accordance with the Declaration of Helsinki and relevant institutional and international ethical guidelines.

6.6. Informed consent

Not applicable.

6.7. Availability of supporting data

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request, subject to institutional and ethical approval requirements.

6.8. Using artificial intelligence chatbots statement

Artificial intelligence-assisted tools were used only for language editing and manuscript preparation. All AI-assisted text

was reviewed and revised by the authors, who take full responsibility for the final manuscript. AI tools were not used for data generation, statistical analysis, or authorship decisions.

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Table 1: Baseline characteristics of studied participants

Variable	Overall (N=372)	PIH		p-value
		No (n=306)	Yes (n=66)	
Age, years	74.9 ± 14.0	74.1 ± 14.3	78.9 ± 11.7	0.005
Male sex	173 (46.5)	140 (45.8)	33 (50.0)	0.530
Pre-intubation SBP, mmHg	129.2 ± 32.1	131.7 ± 31.7	117.6 ± 31.8	0.002
Pre-intubation MAP, mmHg	90.5 ± 21.0	91.9 ± 20.4	83.7 ± 22.6	0.008
Heart rate before intubation, bpm	106.2 ± 24.9	106.5 ± 25.1	104.7 ± 24.1	0.591
Shock index	0.88 ± 0.32	0.86 ± 0.30	0.97 ± 0.40	0.030
O2 sat before intubation, %	92.3 ± 9.0	92.4 ± 8.4	91.7 ± 11.2	0.625
Lactate, mmol/L	3.7 ± 3.3	3.5 ± 3.2	4.6 ± 3.8	0.083
Bicarbonate, mmol/L	19.3 ± 6.0	19.4 ± 6.0	19.0 ± 6.1	0.642
Hemoglobin, g/dL	11.0 ± 2.4	11.0 ± 2.4	10.8 ± 2.1	0.486
Hypertension	277 (74.5)	226 (73.9)	51 (77.3)	0.564
Diabetes mellitus	176 (47.3)	142 (46.4)	34 (51.5)	0.451
Chronic kidney disease	126 (33.9)	102 (33.3)	24 (36.4)	0.637
Heart disease	146 (39.2)	119 (38.9)	27 (40.9)	0.760
COPD/respiratory disease	79 (21.2)	63 (20.6)	16 (24.2)	0.510
Cancer	75 (20.2)	65 (21.2)	10 (15.2)	0.263
Vasopressor before intubation	53 (14.2)	38 (12.4)	15 (22.7)	0.030
Fluid before intubation	222 (59.7)	175 (57.2)	47 (71.2)	0.037
Non-RSI	142 (38.2)	105 (34.3)	37 (56.1)	0.001
Etomidate used	284 (76.3)	245 (80.1)	39 (59.1)	<0.001

Values are presented as mean ± standard deviation (SD) for continuous variables and number (%) for categorical variables. Lactate was available in 255/372 patients. PIH: Post-intubation hypotension; bpm: beats per minute; SBP: systolic blood pressure; MAP: mean arterial pressure; RSI: rapid sequence intubation; COPD: chronic obstructive pulmonary disease. O2 sat: oxygen saturation.

Table 2: Multivariable model for derivation of the simplified PIH score

Predictor	Adjusted OR	95% CI	p-value	Coefficient (β)	Score
Age ≥75 years					
No	1.00	Reference	–	–	0
Yes	2.90	1.52–5.51	0.001	1.064	1
Pre-intubation SBP <110 mmHg					
No	1.00	Reference	–	–	0
Yes	2.18	1.20–3.97	0.011	0.780	1
Non-RSI					
No	1.00	Reference	–	–	0
Yes	2.35	1.32–4.18	0.004	0.854	1
Absence of etomidate use					
No	1.00	Reference	–	–	0
Yes	2.39	1.31–4.35	0.004	0.871	1

OR: odds ratio; CI: confidence interval; SBP: systolic blood pressure; RSI: rapid sequence intubation; PIH: Post-intubation hypotension.

Table 3: Diagnostic performance across score thresholds

Score threshold	Sensitivity	Specificity	PPV	NPV	LR+	LR–
≥1	93.9	15.7	19.4	92.3	1.11	0.39
≥2	74.2	59.2	28.2	91.4	1.82	0.44
≥3	33.3	91.5	45.8	86.4	3.92	0.73
≥4	10.6	98.7	63.6	83.7	8.12	0.91

Sensitivity, specificity, PPV, and NPV are presented as percentages. PPV: positive predictive value; NPV: negative predictive value; LR+: positive likelihood ratio; LR–, negative likelihood ratio.

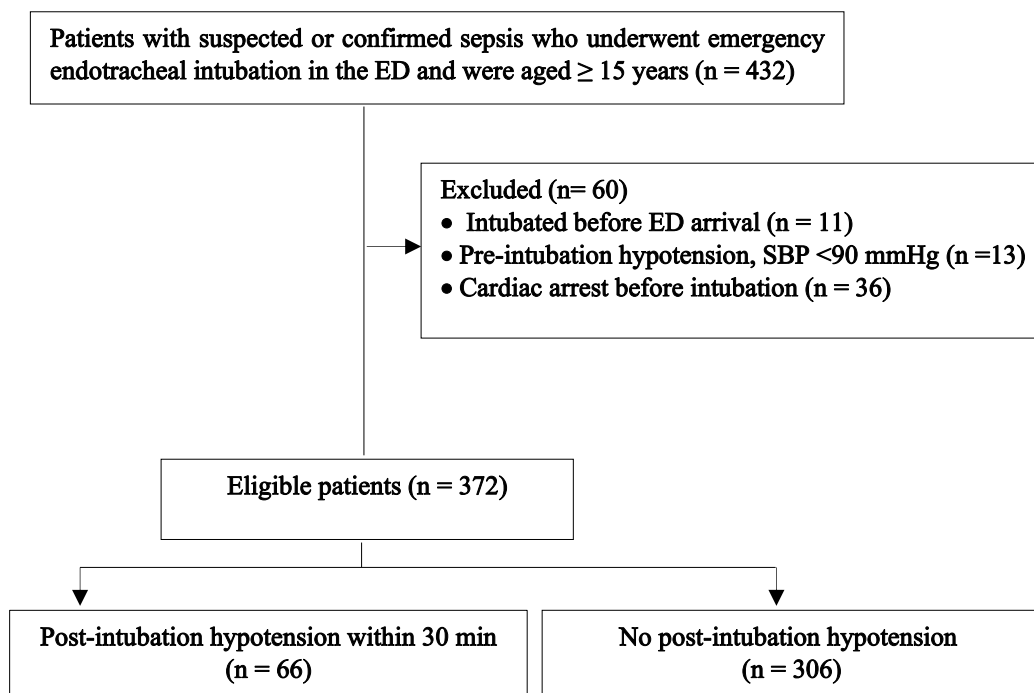


Figure 1: Study flow diagram. ED: Emergency department; SBP: Systolic blood pressure.

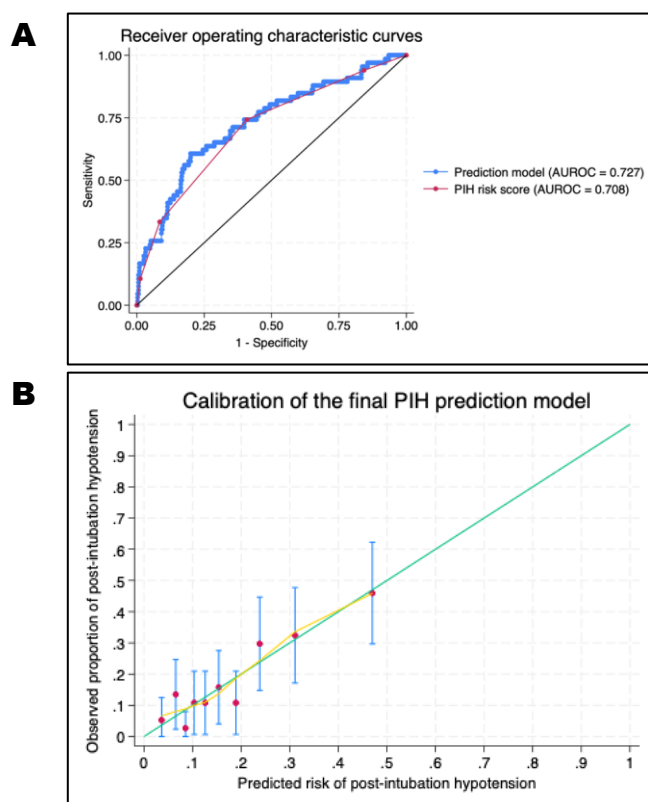


Figure 2: A) Receiver operating characteristic curves of the final continuous prediction model and simplified post-intubation hypotension (PIH) score. The apparent Area under the receiver operating characteristic curves (AUROCs) were 0.727 and 0.708, respectively ($p=0.241$). The optimism-corrected AUROC of the final continuous model after 1,000 bootstrap resamples was 0.711. B) Calibration plot of the final continuous prediction model for post-intubation hypotension.