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Pre-intubation Shock Index as a Predictor of Post-intubation Hypotension in Adult Patients Undergoing Emergency Endotracheal Intubation: A Retrospective Observational Study

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HIGHLIGHTS

- Post-intubation hypotension occurred frequently
- Shock Index strongly predicted hypotension
- Optimal SI cutoff was 0.80
- Hypotension increased in-hospital mortality
- Early optimization improved patient outcomes

Key Words:
Post-intubation hypotension
Shock Index
Emergency endotracheal intubation
Rapid sequence intubation
Hemodynamic instability
Emergency medicine

ABSTRACT

Introduction: Post-intubation hypotension (PIH) is a common complication of emergency endotracheal intubation and is associated with increased morbidity and mortality. Early identification of high-risk patients may enable timely hemodynamic optimization. The Shock Index (SI), calculated as heart rate divided by systolic blood pressure, is a simple bedside marker of circulatory instability. **Aim & Objective:** This study evaluated the incidence, predictors, and clinical impact of PIH, with emphasis on the predictive value of pre-intubation SI. **Materials & Methods:** This retrospective observational study included adult patients undergoing emergency endotracheal intubation at a tertiary care emergency department. Of 435 patients screened, 280 met the inclusion criteria. Demographic, clinical, hemodynamic, and outcome data were obtained from the institutional airway registry and medical records. Independent predictors of PIH were identified using multivariable logistic regression, and receiver operating characteristic (ROC) analysis was used to assess the predictive performance of SI. **Results:** PIH occurred in 62 patients (22.1%). Patients with PIH were significantly older and had a higher prevalence of chronic obstructive pulmonary disease, chronic renal insufficiency, and diabetes mellitus. They also had higher pre-intubation heart rate, lower systolic blood pressure, and higher SI. PIH was associated with increased vasopressor use, post-intubation cardiac arrest, and in-hospital mortality. Pre-intubation SI was the strongest independent predictor of PIH (adjusted OR 48.6, 95% CI 11.2–210.0; $P<0.001$). ROC analysis demonstrated good predictive performance (AUC ≈0.75), with an optimal SI cutoff of 0.80 (68% sensitivity, 80% specificity). **Conclusion:** PIH is a frequent complication of emergency intubation with significant adverse outcomes. Pre-intubation SI is a simple, rapid, and reliable predictor that may facilitate early identification of high-risk patients and guide pre-intubation hemodynamic optimization.

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INTRODUCTION

Emergency endotracheal intubation (ETI) is an essential component of airway management in critically ill patients presenting with respiratory failure, airway compromise, trauma, or altered consciousness. Rapid sequence intubation (RSI), utilizing a rapidly acting induction agent and neuromuscular blocker, is regarded as the standard technique for emergency airway management because it provides optimal intubating conditions while minimizing aspiration and other airway-related complications [1]. Despite advances in airway equipment and standardized RSI protocols, emergency intubation remains a high-risk procedure associated with significant peri-intubation complications, including hypoxemia, esophageal intubation, aspiration, and cardiovascular instability [2,3].

Among these complications, post-intubation hypotension (PIH) has emerged as one of the most clinically important adverse events. PIH results from induction agent-induced sympatholysis, reduced systemic vascular resistance, diminished venous return following positive-pressure ventilation, & limited cardiovascular reserve in critically ill patients [4]. Although transient hypotension has traditionally been regarded as an expected physiological consequence of intubation, increasing evidence suggests that PIH is associated with increased vasopressor requirement, prolonged intensive care stay, organ dysfunction, cardiac arrest, and higher in-hospital mortality [5,6].

Early identification of patients at risk for PIH is therefore essential to facilitate timely hemodynamic optimization before airway intervention. Several clinical factors, including advanced age, chronic kidney disease, chronic obstructive pulmonary disease, diabetes mellitus, respiratory failure, and baseline hemodynamic abnormalities, have been identified as potential predictors of PIH [7]. However, these variables may not always be readily available during emergency airway management, highlighting the need for a rapid and reliable bedside predictor [8].

The Shock Index (SI), defined as the ratio of heart rate to systolic blood pressure, is an inexpensive, non-invasive, and easily obtainable marker of cardiovascular reserve. A normal SI ranges from approximately 0.5 to 0.7, whereas elevated values indicate impaired circulatory reserve despite apparently normal vital signs [9]. Previous studies have demonstrated the superiority of SI over conventional vital signs in predicting adverse outcomes in trauma, sepsis, pulmonary embolism, and other critically ill patients [10,11]. Heffner et al. identified pre-intubation SI as the strongest independent predictor of PIH, with an SI threshold of ≥0.8 demonstrating 67% sensitivity and 80% specificity for predicting post-intubation hypotension [6].

Figure 1. Pre-intubation Shock Index as a predictor of post-intubation hypotension in adult emergency endotracheal intubation.

Recent studies have further validated the role of SI in predicting peri-intubation hemodynamic instability and emphasized the importance of individualized pre-intubation hemodynamic optimization, appropriate induction agent selection, and early vasopressor support in high-risk patients [12–14]. Nevertheless, evidence from tertiary-care emergency departments remains limited, particularly in different patient populations where underlying disease severity and airway management practices may vary. Therefore, the present study was undertaken to determine the incidence of post-intubation hypotension among adult patients undergoing emergency endotracheal intubation, identify independent predictors associated with its occurrence, evaluate the predictive performance of the pre-intubation Shock Index, and assess the impact of PIH on clinically important outcomes including vasopressor requirement, cardiac arrest, and in-hospital mortality.

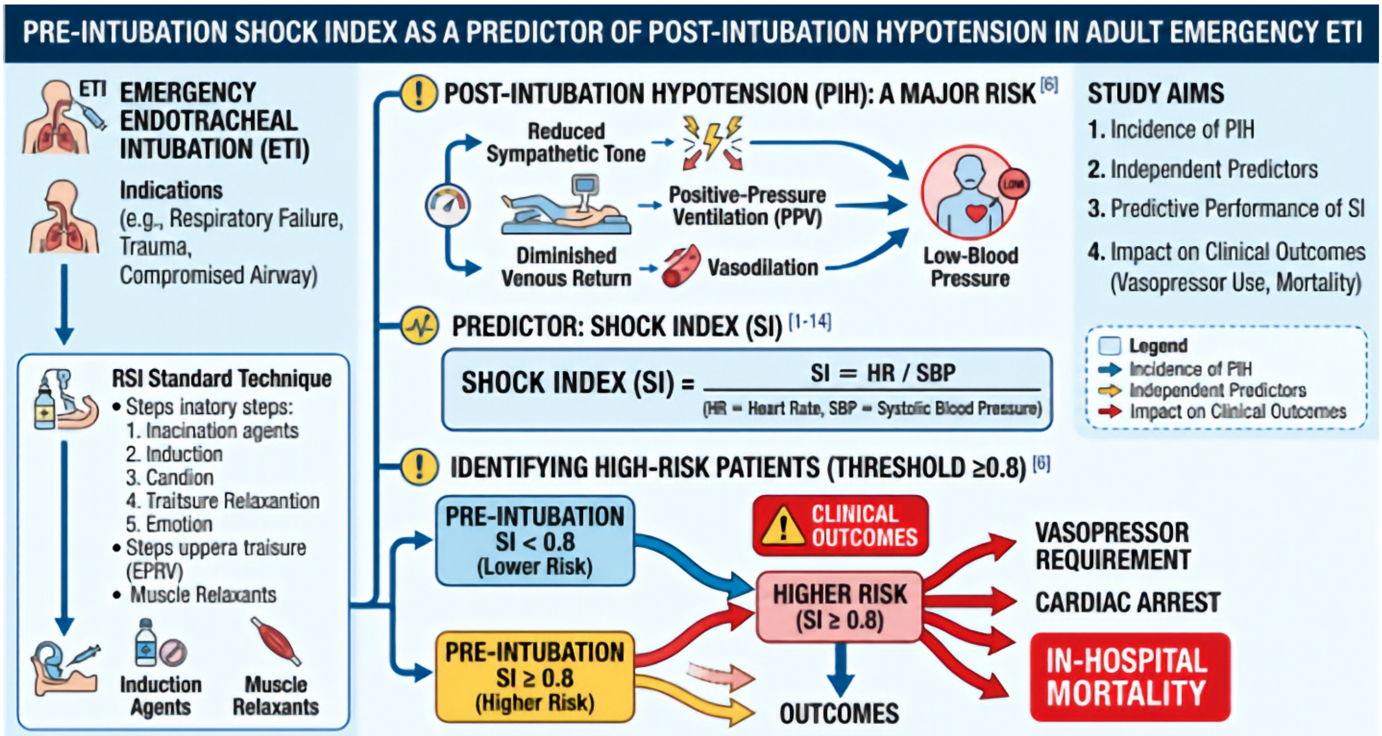

Figure 1: Shock Index predicting post-intubation hypotension.

MATERIALS & METHODS

This was a retrospective observational cohort study conducted at the Emergency Department of a tertiary care teaching hospital. All consecutive adult patients who underwent emergency endotracheal intubation during the study period were identified from the institutional airway registry and electronic medical records. A total of 435 patients underwent emergency intubation during the study period. After applying the predefined eligibility criteria, 280 patients were included in the final analysis.

Study Population: Patients aged 18 years or older who underwent emergency endotracheal intubation in the emergency department were eligible for inclusion. Patients were excluded if they were younger than 18 years, had incomplete airway or predictor data, were intubated before arrival at the emergency department, experienced cardiac arrest before intubation, or had pre-intubation hypotension. The patient selection process is illustrated in **Figure 2**.

Data Collection: Demographic characteristics, comorbid illnesses, indication for intubation, pre-intubation physiological variables, medications used for induction and neuromuscular blockade, and clinical outcomes were extracted from the airway registry and electronic medical records using a standardized data collection form. Recorded hemodynamic variables included heart rate, systolic blood pressure, and pre-intubation Shock Index (heart rate/systolic blood pressure).

Outcome Measures: The primary outcome was the occurrence of post-intubation hypotension (PIH) following emergency endotracheal intubation. Post-intubation hypotension was defined as the development of hypotension requiring therapeutic intervention within the immediate post-intubation period.

Secondary outcomes included:

- Post-intubation cardiac arrest
- Requirement for vasopressor support
- In-hospital mortality
- Time from intubation to development of hypotension

Statistical Analysis: Continuous variables were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR) according to data distribution. Categorical variables were presented as frequencies and percentages.

Comparisons between patients with and without PIH were performed using the independent-samples t-test or Mann-Whitney U test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables. Variables demonstrating clinical relevance or statistical significance on univariate analysis were entered into a multivariable binary logistic regression model to identify independent predictors of PIH. Results were reported as adjusted odds ratios (ORs) with 95% confidence intervals (CIs). Model discrimination was evaluated using the C-statistic, while calibration was assessed using the Hosmer–Lemeshow goodness-of-fit test. Receiver operating characteristic (ROC) curve analysis was performed to determine the predictive performance of the pre-intubation Shock Index and to identify the optimal cutoff value. A two-tailed P value <0.05 was considered statistically significant.

RESULTS

A total of 435 patients underwent emergency intubation during the study period, of whom 280 patients fulfilled the eligibility criteria and were included in the final analysis. Following intubation, 62 patients (22.1%) developed post-intubation hypotension (PIH), while 218 patients (77.9%) remained hemodynamically stable. **Figure 2** illustrates the study flow, including patient selection, reasons for exclusion, and allocation into PIH and non-PIH groups.

Statistical tests: Continuous variables: independent-samples t test or Mann–Whitney U test according to distribution. Categorical variables: χ^2 test/Fisher exact test. Statistical significance: P < 0.05. This follows the approach used in the parent study.

Table 1 summarizes the demographic and baseline clinical characteristics of the study population. Patients who developed PIH were significantly older than those without PIH (54 ± 20 vs. 48 ± 19 years, P=0.038). Chronic obstructive pulmonary disease (19.4% vs. 10.1%, P=0.049), chronic renal insufficiency (16.1% vs. 7.8%, P=0.050), and diabetes mellitus (33.9% vs. 19.3%, P=0.015) were significantly more prevalent in the PIH group. No significant differences were observed with respect to sex, body weight, coronary artery disease, atrial fibrillation, hypertension, asthma, or end-stage renal disease between the two groups. These findings indicate that patients who developed PIH had a higher burden of age-related and chronic comorbidities. **Table 2** compares intubation characteristics and pre-intubation hemodynamic variables between the study groups. Respiratory insufficiency was a more frequent indication for intubation among patients who developed PIH (32.3% vs. 15.1%, P=0.002), whereas airway protection was more common in patients without PIH (83.0% vs. 64.5%, P<0.01). Patients with PIH had significantly higher pre-intubation heart rate (109 ± 24 vs. 100 ± 24 bpm, P=0.011), lower systolic blood pressure (134 ± 41 vs. 158 ± 36 mmHg, P<0.001), and a markedly elevated shock index (0.91 ± 0.30 vs. 0.68 ± 0.20, P<0.001). Although the induction agent used was similar between groups, neuromuscular paralysis during rapid sequence intubation was significantly less frequent in the PIH group (91.9% vs. 99.5%, P=0.002), suggesting important peri-intubation factors contributing to hemodynamic instability. **Table 3** presents the clinical outcomes according to the occurrence of PIH. Patients who developed PIH had significantly higher rates of post-intubation cardiac arrest (9.7% vs. 0.9%, P<0.001) and vasopressor requirement (19.4% vs. 1.4%, P<0.001). In-hospital mortality was also significantly greater among patients with PIH compared with those without PIH (35.5% vs. 19.7%, P=0.009). The median time to development of hypotension after intubation was 11 minutes (IQR 4–27 minutes), indicating that PIH occurred early after airway management and was associated with substantially worse clinical outcomes.

Model performance: C-statistic approximately 0.80; proposed Hosmer–Lemeshow $P > 0.05$, indicating acceptable calibration.

Table 4 demonstrates the results of multivariable logistic regression analysis. Pre-intubation shock index emerged as the strongest independent predictor of PIH (adjusted OR 48.6; 95% CI 11.2–210.0; $P<0.001$). Chronic renal insufficiency, end-stage renal disease, respiratory failure as the indication for intubation, and increasing age were also independently associated with significantly increased odds of PIH. In contrast, ACE-inhibitor therapy and the use of rapid sequence intubation paralysis independently reduced the likelihood of developing PIH. The regression model showed good discrimination (C-statistic ≈0.80) with acceptable calibration, and these independent predictors are illustrated in the forest plot **(Figure 2). Table 5** stratifies the risk of PIH according to pre-intubation shock index categories. A progressive increase in PIH incidence was observed with increasing shock index (P for trend <0.001), rising from 6.9% in patients with shock index <0.50 to 51.7% in those with values between 0.90–1.09. Similarly, the odds of PIH increased substantially across successive shock index categories, demonstrating a clear dose-response relationship. Receiver operating characteristic analysis **(Figure 4)** showed that pre-intubation shock index had good predictive performance for PIH (AUC ≈0.75), with an optimal cutoff value of 0.80, providing approximately 68% sensitivity and 80% specificity. The increasing incidence of PIH across shock index categories is further depicted in **Figure 5.** Overall, the results demonstrate that post-intubation hypotension occurred in approximately one-fifth of patients undergoing emergency intubation and was associated with increased age, greater comorbidity burden, adverse pre-intubation hemodynamic parameters, higher vasopressor requirement, and significantly increased in-hospital mortality. Among all evaluated variables, pre-intubation shock index was the most powerful independent predictor of PIH, exhibiting good discriminatory ability and a strong dose-dependent relationship with the risk of hemodynamic deterioration following emergency intubation.

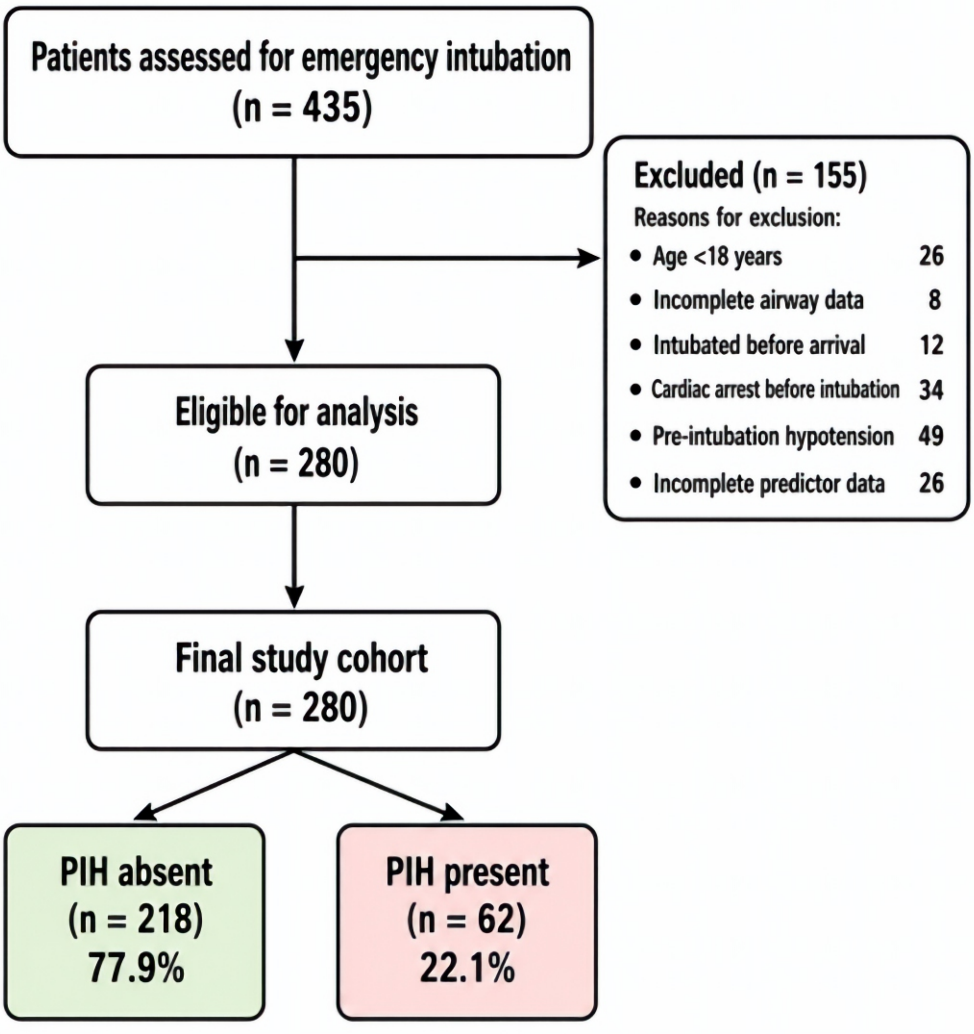

Figure 2. Flow diagram showing patient selection, exclusions, and the final study cohort categorized by the presence or absence of post-intubation hypotension.

Table 1. Demographic and baseline clinical characteristics

Variable	Total n=280	PIH absent n=218	PIH present n=62	P value
Age, years	49.3 ± 19.4	48 ± 19	54 ± 20	**0.038**
Male sex	183 (65.4%)	145 (66.5%)	38 (61.3%)	0.446
Weight, kg	81.4 ± 23.1	81 ± 23	83 ± 24	0.57
Coronary artery disease	26 (9.3%)	18 (8.3%)	8 (12.9%)	0.27
Left ventricular failure	16 (5.7%)	10 (4.6%)	6 (9.7%)	0.13
Atrial fibrillation	25 (8.9%)	17 (7.8%)	8 (12.9%)	0.21
Hypertension	120 (42.9%)	91 (41.7%)	29 (46.8%)	0.48
COPD	34 (12.1%)	22 (10.1%)	12 (19.4%)	**0.049**
Asthma	18 (6.4%)	13 (6.0%)	5 (8.1%)	0.56
Chronic renal insufficiency	27 (9.6%)	17 (7.8%)	10 (16.1%)	**0.050**
End-stage renal disease	17 (6.1%)	10 (4.6%)	7 (11.3%)	0.06
Diabetes mellitus	63 (22.5%)	42 (19.3%)	21 (33.9%)	**0.015**

Table 2. Intubation characteristics and pre-intubation hemodynamics

Variable	Total n=280	PIH absent n=218	PIH present n=62	P value
Medical cases	160 (57.1%)	124 (56.9%)	36 (58.1%)	0.87
Trauma cases	120 (42.9%)	94 (43.1%)	26 (41.9%)	
Airway protection	221 (78.9%)	181 (83.0%)	40 (64.5%)	**<0.01**
Respiratory insufficiency/failure	53 (18.9%)	33 (15.1%)	20 (32.3%)	**0.002**
Other indication	6 (2.1%)	4 (1.8%)	2 (3.2%)	
Pre-intubation HR, bpm	102 ± 25	100 ± 24	109 ± 24	**0.011**
Pre-intubation SBP, mmHg	153 ± 39	158 ± 36	134 ± 41	**<0.001**
Pre-intubation shock index	0.73 ± 0.25	0.68 ± 0.20	0.91 ± 0.30	**<0.001**
Etomidate induction	259 (92.5%)	203 (93.1%)	56 (90.3%)	0.46
RSI paralysis used	274 (97.9%)	217 (99.5%)	57 (91.9%)	**0.002**
Succinylcholine used	238 (85.0%)	185 (84.9%)	53 (85.5%)	0.91

Table 3. Clinical outcomes according to post-intubation hypotension

Outcome	Overall n=280	PIH absent n=218	PIH present n=62	P value
Post-intubation hypotension	62 (22.1%)	—	62 (100%)	—
Post-intubation cardiac arrest	8 (2.9%)	2 (0.9%)	6 (9.7%)	**<0.001**
Vasopressor/catecholamine support	15 (5.4%)	3 (1.4%)	12 (19.4%)	**<0.001**
In-hospital mortality	65 (23.2%)	43 (19.7%)	22 (35.5%)	**0.009**
Median time to PIH	—	—	11 min (IQR 4–27)	—

Table 4. Multivariable logistic regression for predictors of PIH

Predictor	Adjusted OR	95% CI	P value
Pre-intubation shock index	**48.6**	11.2–210.0	**<0.001**
End-stage renal disease	**3.50**	1.05–11.70	**0.041**
Chronic renal insufficiency	**3.20**	1.15–8.90	**0.026**
Intubation for respiratory failure	**2.20**	1.05–4.70	**0.038**
Age, per year	**1.03**	1.01–1.05	**0.006**
ACE-inhibitor use	**0.32**	0.14–0.72	**0.006**
RSI paralysis	**0.05**	0.006–0.41	**0.008**

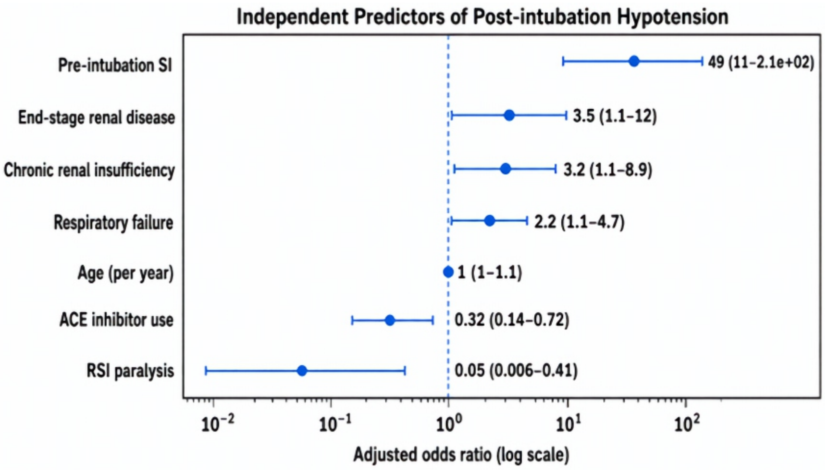

Figure 3. Forest plot depicting adjusted odds ratios and 95% confidence intervals for independent predictors of post-intubation hypotension identified by multivariable logistic regression.

Table 5. PIH risk according to pre-intubation Shock Index

Shock Index	Total	PIH present	PIH absent	OR*
<0.50	58	4 (6.9%)	54 (93.1%)	1.0
0.50–0.69	93	12 (12.9%)	81 (87.1%)	2.0
0.70–0.89	78	20 (25.6%)	58 (74.4%)	4.7
0.90–1.09	29	15 (51.7%)	14 (48.3%)	14.5
>1.10	22	11 (50.0%)	11 (50.0%)	13.5
Total	**280**	**62**	**218**	

*Reference = SI <0.50.

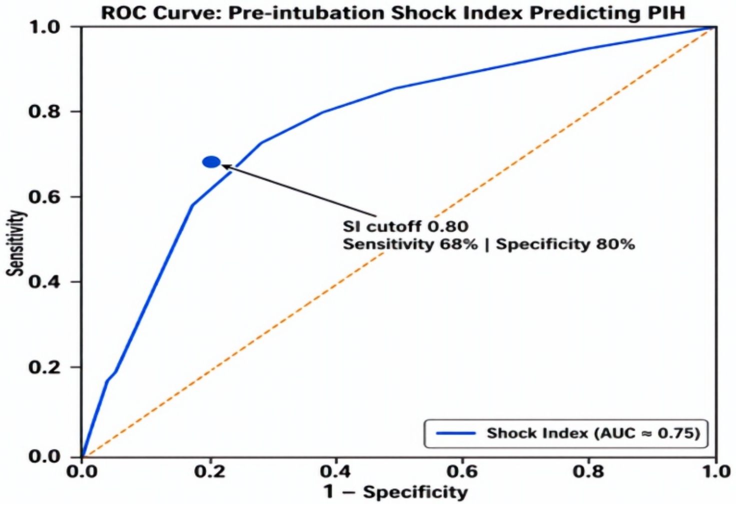

Figure 4. Receiver operating characteristic (ROC) curve demonstrating the predictive performance of pre-intubation shock index for post-intubation hypotension.

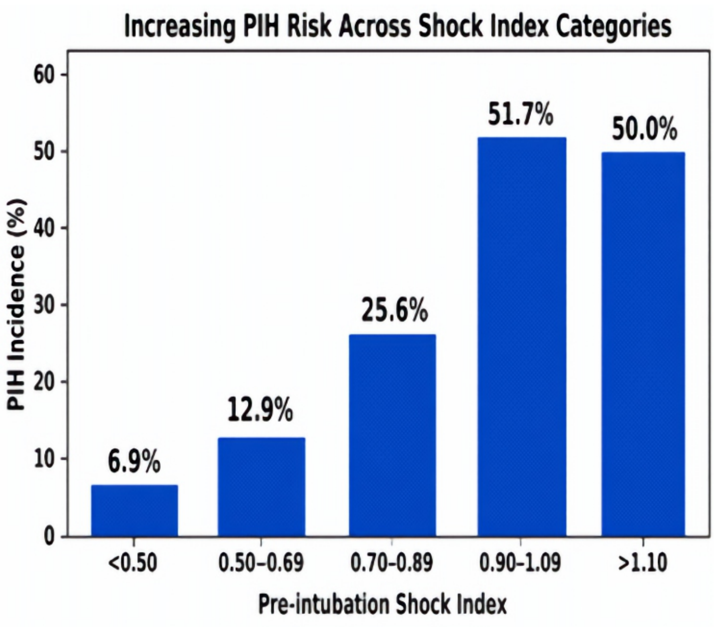

Figure 5. Incidence of post-intubation hypotension across increasing categories of pre-intubation shock index, demonstrating a significant dose-response relationship.

DISCUSSION

In the present study, **post-intubation hypotension (PIH) occurred in 22.1% of patients** undergoing emergency endotracheal intubation. This incidence is consistent with the findings of **Heffner et al.** [6], who reported PIH in approximately one-fifth of emergency intubations, and **Lin et al.** [7], who also demonstrated that hypotension remains one of the commonest cardiovascular complications following rapid sequence intubation. These findings reaffirm that despite improvements in airway management techniques, PIH continues to be an important cause of early post-intubation morbidity.

Patients who developed PIH in our study were significantly older and had a higher prevalence of chronic obstructive pulmonary disease, chronic renal insufficiency, and diabetes mellitus. Similar observations were reported by **Heffner et al.** [6], who identified increasing age and chronic kidney disease as significant predictors of post-intubation hypotension. Likewise, **Lin et al.** [7] found that underlying medical illnesses and impaired physiological reserve predispose patients to peri-intubation hemodynamic instability. Advanced age and chronic systemic diseases reduce cardiovascular compensatory mechanisms, making patients particularly susceptible to the vasodilatory effects of induction agents and the reduction in venous return associated with positive-pressure ventilation.

Our study demonstrated that patients who developed PIH had significantly higher pre-intubation heart rate, lower systolic blood pressure, and a markedly elevated pre-intubation Shock Index (SI). Furthermore, respiratory failure was a significantly more common indication for intubation among patients who subsequently developed hypotension. **Rady et al.** [8,9] first demonstrated that the Shock Index is superior to isolated heart rate or blood pressure in detecting early circulatory compromise, while **Keller et al.** [10] and **Cannon et al.** [11] subsequently validated its prognostic value across critically ill and trauma populations. Our findings further support the utility of SI as an easily obtainable bedside marker of hemodynamic vulnerability before emergency airway intervention.

Multivariable logistic regression identified **pre-intubation Shock Index as the strongest independent predictor** of PIH, followed by chronic renal insufficiency, end-stage renal disease, respiratory failure, and increasing age. These findings closely parallel those of **Heffner et al.** [6], who also reported SI as the most powerful independent predictor after adjustment for multiple confounding variables. In addition, our ROC analysis demonstrated good predictive performance of SI (AUC ≈0.75), with an optimal cutoff value of **0.80**, which is almost identical to that reported by **Heffner et al.** [6]. More recently, **Marks et al.** [12] emphasized the importance of identifying patients at high risk for PIH to facilitate prophylactic vasopressor administration, while **Adisasmita et al.** [13] demonstrated that elevated pre-intubation SI independently predicts hypotension following emergency intubation. Similarly, **Smischney et al.** [14] confirmed that higher shock indices are associated with peri-intubation hypotension and adverse clinical outcomes, further supporting the role of SI in peri-intubation risk stratification.

Consistent with previous literature, patients who developed PIH in our study experienced significantly higher rates of vasopressor requirement, post-intubation cardiac arrest, and in-hospital mortality. **Jones et al.** [5] demonstrated that even transient hypotension is independently associated with increased in-hospital mortality, while **Heffner et al.** [6] similarly reported worse clinical outcomes among patients who developed PIH. These observations emphasize that PIH should not be regarded as a transient physiological event but rather as an important marker of critical illness requiring prompt recognition and aggressive hemodynamic optimization.

The major strengths of the present study include evaluation of a relatively large cohort of emergency intubations, comprehensive assessment of demographic and peri-intubation variables, and application of multivariable logistic regression and ROC analysis to identify independent predictors of PIH.

However, several limitations should be acknowledged. The retrospective single-center design may limit generalizability, and important variables such as illness severity scores, induction drug doses, fluid resuscitation, vasopressor timing, and operator experience were not evaluated. Prospective multicenter studies are warranted to validate these findings and determine whether Shock Index-guided pre-intubation hemodynamic optimization can reduce the incidence of PIH and improve patient outcomes [12–14].

CONCLUSION

Post-intubation hypotension is a frequent complication of emergency endotracheal intubation, occurring in approximately one-fifth of patients and is associated with significantly increased vasopressor requirement, post-intubation cardiac arrest, and in-hospital mortality. Advanced age, chronic renal disease, respiratory failure, and adverse pre-intubation hemodynamic status were important predictors of PIH, while the pre-intubation Shock Index emerged as the strongest independent predictor, demonstrating good discriminative ability with an optimal cutoff value of 0.80. Routine assessment of Shock Index before emergency intubation may facilitate early identification of high-risk patients, allowing timely hemodynamic optimization and targeted preventive strategies to reduce peri-intubation complications and improve clinical outcomes.

LIMITATIONS & FUTURE PERSPECTIVES

The study's limitations include a single-centre setting, a relatively small sample size, and a short study duration, which may limit the broader applicability of the results. Future studies should incorporate multicentre designs with larger populations to enhance validity, assess long-term outcomes, and investigate advanced diagnostic & management approaches. Such efforts will improve overall patient care & help minimize complications.

CLINICAL SIGNIFICANCE

The clinical significance of this study lies in its potential to bridge the gap between research findings and practical healthcare, diagnosis, and treatment outcomes. By highlighting real-care applications. It emphasizes the importance of translating scientific observations into meaningful improvements in patient world relevance, the study contributes to evidence based medical practice and supports informed clinical decision making. Ultimately, the findings aim to enhance patient quality of life, optimize therapeutic strategies, and promote better disease management in clinical settings.

ABBREVIATIONS

PIH: Post-intubation Hypotension
SI: Shock Index
ROC: Receiver Operating Characteristic
AUC: Area Under the Curve
CI: Confidence Interval
COPD: Chronic Obstructive Pulmonary Disease
ED: Emergency Department
ETI: Endotracheal Intubation

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AUTHOR CONTRIBUTIONS

All authors significantly contributed to the study conception and design, data acquisition, or data analysis and interpretation. They participated in drafting the manuscript or critically revising it for important intellectual content, consented to its submission to the current journal, provided final approval for the version to be published, and accepted responsibility for all aspects of the work. Additionally, all authors meet the authorship criteria outlined by the International Committee of Medical Journal Editors (ICMJE) guidelines.

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CONFLICT OF INTEREST

Authors declared that there is no conflict of interest.

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ETHICAL APPROVAL & CONSENT TO PARTICIPATE

All necessary consent & approval was obtained by authors.

CONSENT FOR PUBLICATION

All necessary consent for publication was obtained by authors.

DATA AVAILABILITY

All data generated and analyzed are included within this research article. The datasets utilized and/or analyzed in this study can be obtained from the corresponding author upon a reasonable request.

USE OF ARTIFICIAL INTELLIGENCE (AI) & LARGE LANGUAGE MODEL (LLM)

The authors confirm that no AI & LLM tools were used in the writing or editing of the manuscript, and no images were altered or manipulated using AI & LLM.

AUTHOR'S NOTE

This article serves as an important educational tool for the scientific community, offering insights that may inspire future research diretions. However, they should not be relied upon independently when making treatment decisions or developing public health policies.

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