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Original Research Article

ASSOCIATION BETWEEN SHOCK INDEX AND POST-EMERGENCY INTUBATION HYPOTENSION IN PATIENTS WHO CALLED THE RAPID RESPONSE TEAM AT DR. CIPTO MANGUNKUSUMO HOSPITAL

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ABSTRACT

Introduction: Hypotension is an acute complication following Emergency Endotracheal Intubation (ETI) in populations who called the Rapid Response Team (RRT). Thus, a fast and simple tool is needed to identify the risk of Post-emergency Intubation Hypotension (PIH). Shock Index (SI) pre-intubation is one of the potential factors to predict PIH. **Objective:** To measure the association between shock index with post-emergency intubation hypotension after calling for the RRT. **Methods:** This research is a cohort retrospective study that analyzed 171 patients aged ≥18 years who have called RRT and underwent an emergency ETI. The cut-off point for SI was determined using the ROC curve to predict PIH. The modification effect was evaluated using stratification analysis. Data were analyzed using cox regression to determine the likelihood of SI in the cause of hypotension. **Result**: A total of 92 patients (53.8%) underwent post-emergency intubation hypotension. The SI cut-off point of 0.9 had a sensitivity of 82.6% and a specificity of 67.1% for predicting PIH (Area Under Curve (AUC) 0.81; 95% CI 0.754–0.882, p <0.05). The increased risk of PIH associated with high SI score was an aRR of 1.9; 95% CI 1.03–3.57, a p-value of 0.040 among those with sepsis, and an aRR of 7.9, 95% CI 2.36–26.38, a p-value of 0.001 among those without sepsis. **Conclusion:** This study showed that a high SI score was associated with PIH after being controlled with other PIH risk variables. The risk of PIH associated with SI score modestly increased (2-fold increase) in those with sepsis and significantly increased (8-fold increase) in those without sepsis.

Keywords: Critical Illness; Emergency Intubation; Post-Intubation Hypotension; Rapid Response Team; Shock Index

ABSTRAK

Pendahuluan: Hipotensi merupakan komplikasi akut yang rentan dialami pasca dilakukan intubasi emergensi pada populasi yang diaktivasi tim respons cepat, maka diperlukan alat untuk identifikasi risiko hipotensi pasca emergensi endotrakeal intubasi dengan cepat dan mudah dilakukan. Indeks syok (IS) sebelum intubasi adalah salah satu faktor yang potensial dalam memprediksi kejadian Hipotensi Pasca-Intubasi Emergensi (HPI). **Tujuan:** Untuk mengetahui hubungan indeks syok sebelum intubasi dengan kejadian hipotensi pasca intubasi. **Metode:** Penelitian ini studi kohort retrospektif yang terdiri 171 pasien berumur ≥18 tahun yang diaktivasi tim respons cepat dan dilakukan intubasi emergensi. Penentuan titik potong syok indeks yang dapat memprediksi hipotensi dengan kurva ROC. Analisis stratifikasi dilakukan untuk mengetahui efek modifikasi. Untuk mengetahui besar risiko SI terhadap hipotensi maka data dianalisis menggunakan cox regresi. **Hasil:** Terdapat 92 pasien (53,8%) yang mengalami hipotensi pasca intubasi emergensi. Nilai titik potong IS yang diambil untuk meprediksi hipotensi adalah 0,9 dengan sensitivitas 82,6% dan spesifisitas 67,1% (area under curve (AUC) 0,81; 95%CI 0,754–0,882, p<0,05). Peningkatan risiko HPI berhubungan dengan skor IS yang tinggi sebesar aRR 1,9 95%CI 1,03–3,57; p-value 0,040 pada yang sepsis dan aRR 7,9; 95%CI 2,36–26,38; p-value 0.001 pada pasien yang tidak sepsis. **Kesimpulan**: Studi ini menunjukkan bahwa skor SI yang tinggi meningkatkan risiko HPI setelah dikontrol dengan variabel lain yang berisiko terhadap HPI. Peningkatan risiko HPI berhubungan dengan skor SI yaitu pada mereka yang sepsis meningkat 2 kali, dan pada yang tidak sepsis sebesar 8 kali.

Kata kunci: Penyakit Kritis; Intubasi Emergensi; Hipotensi Pasca-Intubasi; Tim Respons Cepat; Indeks Syok

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INTRODUCTION

Any patient from all hospital units can worsen and become critically ill (1). Therefore, critical care management should be provided and accessible in the hospital environment. To do so, the implementation of a Rapid Response Team (RRT) has been proposed to identify and provide initial care for critically ill patients (2,3). A common emergency procedure provided by the RTT is Emergency Endotracheal Intubation (ETI). It is generally performed on critically ill patients to improve oxygenation and ventilation (4).

Endotracheal Intubation is more challenging for doctors to perform in emergency situations. It is associated with an increased risk of adverse events compared to elective intubation in the operating room (4,5). These risks include the critically ill patient's susceptibility to developing hypoxia and hypotension after this life-saving procedure. Post-Intubation Hypotension (PIH) is significantly associated with poor outcomes such as increasing the risk of mortality, kidney injury, myocardial injury, and Intensive Care Unit (ICU) length of stay (6,7). Therefore, to prevent these outcomes, it is vital to identify susceptible patients, especially in emergency settings.

Measurement of vital signs by calculating the Shock Index (SI) before intubation is a simple bedside and effective tool for predicting early shock than using a single parameter. SI can be defined as the ratio of Heart Rate (HR) to Systolic Blood Pressure (SBP), with a normal range of 0.5-0.7 (7–9). The prevalence of PIH in the SI of <0.7 group (23%) was lower than those in the SI of ≥0.7 (37.5%) group of patients who underwent intubation in the emergency department (8). The study presented that subjects who had a pre-intubation SI of ≥0.8 were more susceptible to experiencing PIH (OR 2.28; 95% CI 1.18-4.43) (10). Another study of 140 patients admitted to the ICU showed that a SI of ≥0.9 was a predictor for PIH (P=.01; OR 3.17; 95% CI 1.58–26.48) (5).

SI has been used commonly in the emergency room and ICU to assess disease severity and initiate therapy to optimize perfusion (9). The usefulness of SI for predicting PIH has been previously studied. However, no studies have focused on evaluating SI for predicting PIH outside the ER or ICU. There were also various cut-off points of SI for predicting PIH.

One of the RRT actions during resuscitation, which is quite often done, is emergency intubation. However, the RRT still lacks data on this topic. Thus, this study's samples were patients who called the RRT. This study aims to measure the association between SI and post-ETI hypotension after RRT activation.

METHODS

Study setting and population

We conducted a retrospective cohort study of patients admitted to Dr. Cipto Mangunkusumo Hospital, a national referral center and teaching hospital. The subjects included in this study were patients ≥18 years and required an ETI to be performed by RRT doctors in all in-hospital units except the ICU, emergency room, and operating room.

The RRT consists of intensivists, anesthesiologists, anesthesia residents, and general practitioners trained in critical care. The team provides immediate assistance to all emergency calls from hospital units except the ICU, emergency, and operating room. Emergency endotracheal intubation is typically performed by anesthesia residents or general practitioners and supervised by anesthesiologists.

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The exclusion criteria in this study were patients with an SBP less than 90 mmHg or Mean Arterial Pressure (MAP) less than 65 mmHg, have undergone cardiac arrest, or missing blood pressure and heart data rate pre- and or post-emergency endotracheal intubation.

Study protocol and measurements

The ethics commissions approved the KET.143/UN2.F1/ETIK/PPM.00.02/2022. Data were retrieved through electronic medical records and RRT documentation after sorting for all potential subjects with a code for endotracheal intubation. Furthermore, the shock index was calculated by dividing HR with SBP and assessing whether PIH occurred post-ETI. PIH was defined as any recorded SBP less than 90 mmHg, as when SBP decreases more than 20% from the baseline, an MAP less than 65 mmHg, or initiating or increasing the vasopressor dose in 30 minutes post-intubation (7).

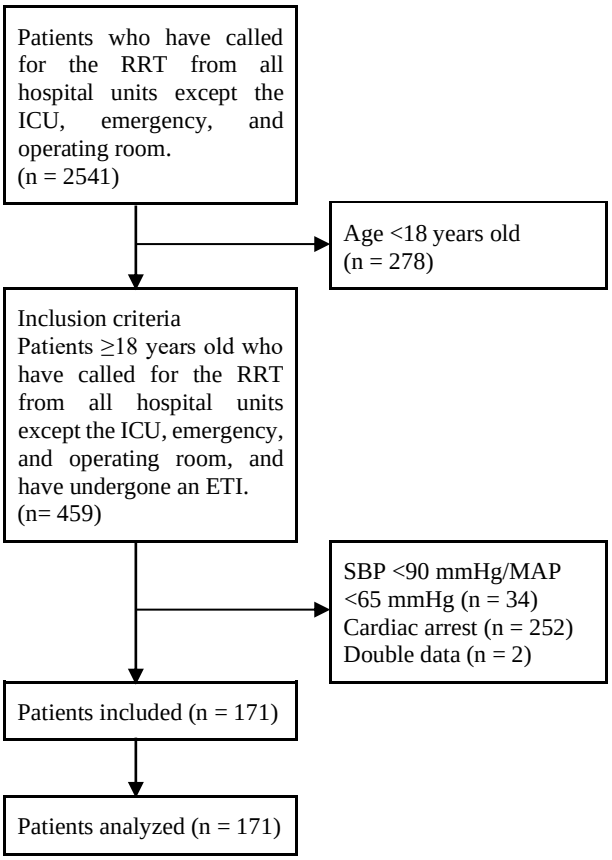

Figure 1. Study Flow Chart

Sampling was conducted from January 2020 to December 2021 (Figure 1). The demographic data used were age, sex, and length of hospitalization. Clinical features included comorbidities, hemodynamic data pre- and post-intubation, and medication for intubation.

Statistical analysis

Continuous variables were presented by mean ±SD or median (interquartile range/IQR) depending on the data distribution. Meanwhile, categorical variables were mentioned as frequency (percentage).

The cut-off point of the shock index was determined using the ROC curve to predict the PIH, which was then calculated by the Youden index. The results were then divided into two categories for further analysis.

Stratification analysis was performed to evaluate the modification effect. Since PIH is considered a common outcome (6,11), using a logistic regression would result in an overestimated relative risk (12). To overcome this issue, the Cox regression analysis calculates the RR (Risk Ratio) by assigning the same survival time for all observations (13). Analysis was done by Stata/SE 16.1, and the significance is indicated by a level of less than 0.05.

RESULTS AND DISCUSSION

The demographic and clinical data are presented in Table 1. Regarding outcomes, 92 patients (53.8%) experienced PIH, and 79 patients (46.2%) did not. The median age of patients was 51.9 (IQR, 18.5 – 89.3), and 53.8% were male. This finding is similar to a previous study which found that 52% of their subjects who experienced PIH were aged 56 years (14). The rate of PIH in this study is higher than in previous studies, which reported 46% (4) and 29.6% incidence (8). Another study revealed

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PIH rates of 19.6%, which excluded patients who used vasopressor pre-intubation (10). These varying results may be due to differences in the definitions of PIH because there is no consensus on its definition. The most significant relationship to mortality was using the vasopressor post-intubation (14).

Table 1. Demographic and Clinical Data

Variable	Value
Post-intubation hypotension	
Yes, n (%)	92 (53.8)
No, n (%)	79 (46.2)
Sex	
Male, n (%)	92 (53.8)
Female, n (%)	79 (46.2)
Age, median (range)	51.9 (18.5 – 89.3)
Intubation reason	
Respiratory failure, n (%)	113 (66.1)
Airway protection, n (%)	12 (7)
Loss of consciousness, n (%)	46 (26.9)
Hemodynamic assessment (pre-intubation)	
Heart rate, median (range)	121 (60 – 188)
SBP (mmHg), median (range)	131 (90 – 217)
MAP, median (range)	96.7 (66 – 185.7)
Time to call RRT from admission, median (range)	7 (0 – 53)
SI (pre-intubation), median (range)	0.9 (0.3 – 1.9)
Comorbidities	
Malignancy, n (%)	56 (32.7)
CHF, n (%)	16 (9.4)
CKD, n (%)	44 (25.7)
COPD, n (%)	4 (2.3)
Diabetes Mellitus, n (%)	47 (27.5)
Hypertension, n (%)	47 (27.5)
Hepatic cirrhosis, n (%)	4 (2.3)
Sepsis, n (%)	104 (60.8)
Intubation medication	
Fentanyl, n (%)	165 (96.5)
Midazolam, n (%)	65 (38)
Ketamine, n (%)	95 (55.6)
Propofol, n (%)	120 (70.2)
Rocuronium, n (%)	47 (27.5)

SBP, Systolic blood pressure; MAP, mean arterial pressure; RRT, Rapid Response Team; SI, Shock index; CHF, Congestive heart failure; CKD, Chronic kidney disease; COPD, Chronic obstructive pulmonary disease

To some extent, the incidence of PIH may be influenced by factors such as study design, hospital setting, and geographic location (15). Table 1 shows that more than 65% of intubation cases were due to respiratory failure. Regarding the patient's hemodynamic status pre-intubation, the results showed that the median heart rate, SBP, and MAP were 113 x/minutes, 131 mmHg, and 96.7 mmHg, respectively. The median time to call RRT from admission was 7 days (IQR, 0 – 53). These results are in line with a previous study that found adult patients who called the RRT 7 days after admission did not survive, and those who called after 5 days survived (16). Furthermore, the prolonged length of stay (LOS) may be due to the increased complications experienced by the patients (17).

An ROC analysis of the SI score calculated that the SI cut-off point of 0.9 had a sensitivity of 82.6% and a specificity of 67.1% for predicting PIH (Area Under Curve (AUC) 0.81, 95% CI 0.754–0.882, p <0.05, Fig. 2). Based on an SI threshold of 0.9, table 2 showed that patients with a high SI score (SI score ≥0.9) were significantly likely to experience PIH than those with a low SI score (SI score <0.9) (RR 3.2 95%CI 2.06–5.01; p-value <0.001).

The results of this study are similar to a study done by Trivedi et al. (5), which showed that a SI score greater than or equal to 0.9 had a significant association with PIH (OR 3.17, 95%CI 1.36–7.73, p-value 0.01) and higher ICU mortality (OR 5.75; 95%CI 1.58–26.48, p-value 0.01). Conversely, a study by Koby A et al. (10) found that PIH was associated with SI scores greater than or equal to 0.8 (OR 2.28; 95% CI 1.18–4.43). The likely reason for these differences may be caused by the influence of the patient's characteristics and the intubation methods performed. However, these results revealed that increasing the SI score may be useful for predicting PIH. Thus, using the SI score is a more effective tool for assessing acute critical illness than conventional vital signs (5).

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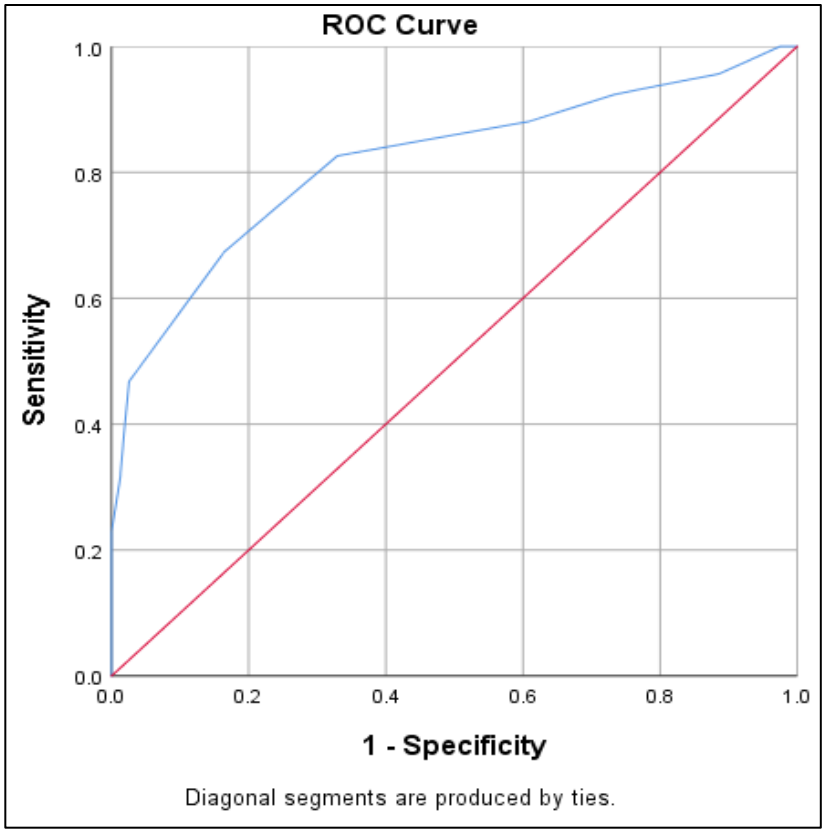

Figure 2. ROC curve for SI score for predicting post-emergency endotracheal intubation

Regarding comorbidities, malignancy occurred in about 69.6% of patients who developed PIH (RR 1.5, 95%CI 1.16–1.96; p = 0.004). The bivariate analysis showed that the association between chronic kidney disease (RR 0.7 95%CI 0.44–0.98; p = 0.019), diabetes mellitus type 2 (RR 0.7 95%CI 0.47–1.00; p = 0.031), and hypertension (RR 0.7 95% CI 0.47–1.00; p = 0.031) were statistically significant with PIH (Table 2).

Furthermore, patients who experienced PIH had a higher prevalence of sepsis than those without PIH (60.6% vs. 39.4%, p = 0.027). We also discovered that all pre-medications before intubation did not differ between the two groups for the risk of PIH.

Moreover, Table 3 shows that sepsis modified the effect of the shock index on the development of PIH. The significance of the homogeneity test was 0.01. The risk ratio of experiencing PIH due to shock index was 1.7 (95% CI 1.20–2.44) among those with sepsis and 4.9 (95% CI 2.46–9.61) among those without sepsis.

Next, multivariable analysis was done using the Cox regression to assess the association between SI score and PIH. In this analysis, potential confounders were controlled, and the interaction terms were tested. The interaction between SI score and sepsis was found to be statistically significant. The adjusted RR (aRR) was 1.9 (95%CI 1.03–3.57, p-value 0.040) among those with sepsis and 7.9 (95%CI 2.36–26.38, p-value 0.001) among those without sepsis after controlling for age, sex, malignancy, and propofol (Table 4).

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Table 2. Association between the SI and Covariate Variables with PIH

Variable	PIH		RR (95% CI)	p-value
	Yes N = 92	No N = 79		
SI score				
High (≥0.9)	76 (74.5)	26 (25.5)	3.2 (2.06–5.01)	<0.001*
Low (<0.9)	16 (23.2)	53 (76.8)		
Age				
≥65 years old	18 (42.9)	24 (57.1)	0.7 (0.51–1.09)	0.101
<65 years old	74 (57.4)	55 (42.6)		
Sex				
Male	41 (44.6)	51 (55.4)	1.4 (1.09–1.92)	0.009*
Female	51 (64.6)	28 (35.4)		
Malignancy				
Yes	39 (69.6)	17 (30.4)	1.5 (1.16–1.96)	0.004*
No	53 (46.1)	62 (53.9)		
CHF				
Yes	6 (37.5)	10 (62.5)	0.7 (0.35–1.29)	0.169
No	86 (55.5)	69 (44.5)		
CKD				
Yes	17 (38.6)	27 (61.4)	0.7 (0.44–0.98)	0.019*
No	75 (59.1)	52 (40.9)		
COPD				
Yes	2 (50)	2 (50)	0.9 (0.34–2.49)	0.877
No	90 (53.9)	77 (46.1)		
T2DM				
Yes	19 (40.4)	28 (59.6)	0.7 (0.47–1.00)	0.031*
No	73 (58.9)	51 (41.1)		
Hypertension				
Yes	19 (40.4)	28 (59.6)	0.7 (0.47–1.00)	0.031*
No	73 (58.9)	51 (41.1)		
Hepatic cirrhosis				
Yes	2 (50)	2 (50)	0.9 (0.34–2.49)	0.877
No	90 (53.9)	77 (46.1)		
Sepsis				
Yes	63 (60.6)	41 (39.4)	1.4 (1.02–1.92)	0.027*
No	29 (43.3)	38 (56.7)		
Fentanyl				
Yes	87 (52.7)	78 (47.3)	0.6 (0.43–0.93)	0.139
No	5 (83.3)	1 (16.7)		
Midazolam				
Yes	36 (55.4)	29 (44.6)	1.0 (0.79–1.39)	0.745
No	56 (52.8)	50 (47.2)		
Ketamine				
Yes	54 (56.8)	41 (43.2)	1.1 (0.85–1.51)	0.372
No	38 (50)	38 (50)		
Propofol				
Yes	63 (52.5)	57 (47.5)	0.9 (0.69–1.24)	0.601
No	29 (56.9)	22 (43.1)		
Rocuronium				
Yes	27 (57.4)	20 (42.6)	1.1 (0.81–1.47)	0.556
No	65 (52.4)	59 (47.6)		

*) Significance test if p-value <0.05; RR=Risk Ratio; PIH=Post-Intubation hypotension; SI=Shock index; CHF=Congestive heart failure; CKD=Chronic kidney disease; COPD=Chronic obstructive pulmonary disease; T2DM=Type 2 Diabetes Mellitus

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Table 3. Stratification Analysis Results of the Association of SI with PIH based on Covariate Variables

Covariate variable	RR strata	95% CI	RR MH (95%CI)	ΔRR (%)	p-value homogeneity test
Age					
<65 years old	2.6	1.76–3.84	2.49 (1.78–3.48)	0.8	0.63
≥65 years old	2.2	1.15–4.08			
Sex					
Male	2.7	1.79–4.16	2.49 (1.79–3.47)	0.8	0.58
Female	2.3	1.34–3.77			
Malignancy					
Yes	3.6	1.51–8.56	2.57 (1.82–3.63)	2.4	0.32
No	2.3	1.59–3.28			
CHF					
Yes	1.3	0.41–3.77	2.51 (1.79–3.51)	0	0.20
No	2.6	1.86–3.80			
CKD					
Yes	2.6	1.36–4.89	2.46 (1.77–3.43)	2.0	0.87
No	2.4	1.65–3.57			
COPD					
Yes	2.0	0.50 –7.99	2.51 (1.81–3.49)	0	0.74
No	2.5	1.81–3.54			
T2DM					
Yes	3.9	1.88–8.19	2.41 (1.75–3.32)	3.9	0.13
No	2.1	1.46–2.99			
Hypertension					
Yes	2.6	1.35–4.91	2.45 (1.76–3.40)	2.4	0.86
No	2.4	1.64–3.53			
Hepatic cirrhosis					
Yes	1.0	0.14–7.09	2.51 (1.80–3.49)	0	0.35
No	2.6	1.83–3.59			
Sepsis					
Yes	1.7	1.20–2.44	-	-	0.01*
No	4.9	2.46–9.61			
Fentanyl					
Yes	2.5	1.79–3.45	2.53 (1.82–3.53)	-	-
No	-	-			
Midazolam					
Yes	2.3	1.38–3.96	2.51 (1.81–3.48)	0	0.73
No	2.6	1.72–3.99			
Ketamine					
Yes	2.1	1.47–3.12	2.45 (1.78–3.83)	2.4	0.29
No	3.1	1.70–5.68			
Propofol					
Yes	2.7	1.86–3.95	2.52 (1.82–3.50)	0.4	0.48
No	2.1	1.06–4.01			
Rocuronium					
Yes	3.4	1.57–7.39	2.52 (1.81–3.51)	0.4	0.36
No	2.3	1.59–3.29			

*) Significance test if p-value <0.05; OR Crude 2.51 (95% CI 1.81–3.49); RR=Risk Ratio; MH=Mantel-Haenszel; PIH=Post-emergency Intubation Hypotension; SI=Shock index; CHF=Congestive Heart Failure; CKD=Chronic Kidney Disease; COPD=Chronic Obstructive Pulmonary Disease; T2DM=Type 2 Diabetes Mellitus

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Table 4. High vs. Low SI Score Associated with PIH by Sepsis

Variable	aRR (95% CI)	p-value
Sepsis		
Yes	1.9 (1.03–3.57)	0.040*
No	7.9 (2.36–26.38)	0.001*

*) Significance test if p-value <0.05
High (≥0.9) vs Low (<0.9); SI=Shock index; PIH=Post-emergency Intubation Hypotension
OR adjusted by age, sex, malignancy, propofol.

Malignancy may cause the patients to become immunocompromised. Therefore, patients with cancer tend to be susceptible to mortality-related factors such as acute respiratory failure or sepsis (18).

According to a previous study, propofol was the most significant factor associated with PIH (aOR 2.16, 95% CI 1.43–3.25, p-value <0.001) (11). It has a short duration of action and rarely results in allergies. However, propofol has the disadvantage of causing hemodynamic instability (11,19).

Next, Wira et al. (20) reported that a SI elevation greater than 0.8 might be a convenient modality to identify patients with severe sepsis. Sepsis is a life-threatening organ dysfunction caused by a dysregulated host response to infection (21). A common complication of sepsis is cardiovascular dysfunction (22). Therefore, sepsis may be given a modification effect for its association between SI and hypotension.

These results could be warning signs for hospitals to modify pre-intubation or peri-intubation management to avoid hemodynamic collapse. High-risk patients, especially those with SI scores of 0.9 or higher, must receive hemodynamic optimization to balance their respiratory and cardiovascular status. Thus, the interventions that the RRT needs to perform during pre-intubations are administering intravenous fluid bolus, using a vasopressor, and choosing an induction agent that fits the patient's hemodynamic needs.

To the best of our knowledge, this is the first study that evaluates the SI in patient populations who have called for the RRT. These results may be the basis for future research regarding the potential of the SI factor to predict PIH in RRT populations.

However, there are several limitations to our study. First, it is a retrospective observational study. Thus, gaps still exist due to missing data. Second, our results may not be generalizable to other populations or centers.

CONCLUSION

Our study showed that the high SI score group was associated with PIH after being controlled with other PIH risk variables. The risk of PIH associated with SI score was modestly increased (2-fold increase) in those who had sepsis and very high (8-fold increase) in those who did not.

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Conflict of Interest

The authors have no conflict of interest to declare.

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None to declare.

Authors' Contributions

All authors have contributed to all processes in this research.

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