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Research Article

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Association Between Patient Signs and Symptoms and Critical Care Center Admissions in Prehospital Settings: A Retrospective Observational Study

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Abstract

Background: *The system to ensure the quality of care when doctors entrust prehospital care to qualified non-doctors is called Medical Control (MC) in Japan. There have been few previous studies that have focused on prehospital care as a way to predict admission to critical care centers. Therefore, we attempted to clarify the factors in prehospital settings that predict admission to critical care centers. We believe that this will help establish an MC system,including the role of emergency medical technicians (EMTs) and doctors in selecting emergency transport destinations.*

Methods: *This retrospective observational study included 1685 adult patients admitted through the Emergency Department (ED) of a 700-bed tertiary care facility over a 9-month period. The main predictive variables were prehospital patient factors, which were broadly categorized into vital signs, signs of shock, and respiratory symptoms. Prehospital patient factors were collected from prehospital records registered inelectronic medical records, and a multivariate logistic regression model was used to analyze the association between prehospital patient factors and admission to the critical care center.*

Results: *A total of 1,685 patients who did not meet the exclusion criteria out of 2,353 patients transported by emergency were analyzed: 350 patients were admitted to the critical care center, 642 patients were admitted to the general ward, and 693 patients returned home. The subjects were patients who were rushed to the ED, and patient data were collected from electronic medical records and emergency transport forms. The level of consciousness, cyanosis, skin wetness or coldness at the time of contact with emergency services were significantly associated with admission to the critical care center (OR 0.92 [0.87-0.97], $p = 0.001$;OR 2.93 [1.75-4.92], $p < 0.001$; OR 3.87 [2.63-5.67], $p < 0.001$;OR 9.57 [5.18-18.3], $p < 0.001$).*

Conclusion: *In a prehospital setting, the level of consciousness and signs of shock were suggested to be associated with admission to critical care centers.*

Keywords: Prehospital, Signs of Shock, Vital Signs, Respiratory Symptoms, Emergency Medical Technicians (EMTs)

Abbreviations

APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; ED, emergency department; FiO_2, Fraction of inspired oxygen; GCS, Glasgow Coma Scale; ICU, intensive care unit; IQR, interquartile range; MBP, Mean blood pressure; MC, Medical Control; SpO_2, percutaneous arterial oxygen saturation; VIF, Variance Inflation Factor

1. Introduction

Medical Control (MC) delineates a healthcare system wherein the formulation of operational protocols, counsel and directives from medical professionals, retrospective validation, education ensuring the proficiency of emergency medical technicians (EMTs), and the designation of roles in determining emergency transport destinations are legislatively mandated. For some time now, the progress of MCs in Japan has exhibited a discernible lag when compared to advancements in analogous systems in nations like the United States, the United Kingdom, Germany, Sweden, and France. It has been seen as a problem that emergency transport and emergency medical resources are not being utilized appropriately in local medical care due to inappropriate emergency transport [1]. In order to carry out appropriate transportation, it is necessary to appropriately judge the degree of urgency and severity based on observation of the patient at the scene. In the process of choosing an optimal transport destination, the ability to anticipate admission to a critical care center based on pre-hospital information affords the prospect of selecting a medical institution equipped with ample resources and personnel. This, in turn, holds promise for enhancing the overall prognosis of the patient. In addition, previous research has shown that the recognition of serious illnesses in prehospital settings can lead to patients being retransferred to urban areas or receiving specific treatments before arriving at the hospital [2,3]. Japan is aiming to reduce the number of beds from 730,000 beds in 2020 to 532,000 beds in Japan, increasing the need to transport patients with appropriate severity to hospitals with appropriate functions and roles [4].

Vital signs are important to make clear decisions within the limited prehospital time frame. In intensive care units (ICU) and general wards, vital signs can predict a worsening of clinical symptoms [5]. Tracking vital signs over time has been shown to improve the accuracy of detecting patients at high risk of acute deterioration and death [6]. Previous studies have looked into in-hospital mortality, cardiac arrest, and the effectiveness of scoring systems that use vital signs. Nevertheless, the main focus of these studies has been on in-hospital management [7-10]. There are previous studies that looked at predicting admission from the emergency department (ED) to a critical care center, and one other study showed a correlation between prehospital and ED vital signs [11-13]. Few previous studies have focused on the prehospital and predicted critical care center admissions [14]. Therefore, weinvestigated the relationship between prehospital patient factors and admission to a critical care center and considered how to improve MC efficiency in the future.

2. Materials and Methods

2.1 Study Design, Population, and Setting

This study was a single-center, retrospective, observational study conducted at the NHO Kure Medical Center and Chugoku Cancer Center. The hospital is a National Hospital Organization with clinical, teaching, and research functions. The hospital has 700 beds and is open 24 hours a day. This emergency hospital provides intensive care services for multiple traumas, severe burns, sepsis, and cardiovascular surgery, etc. to citizens of the Kure secondary medical care area located in the southwestern part of Hiroshima Prefecture (there were approximately 230,000 people in the area in 2020). The critical care center at the facility accepts tertiary emergency patients and has 6 ICU beds and 18 other beds. At NHO Kure Medical Center and Chugoku Cancer Center, on average 250 people used the ambulance each month in 2020. Of these, average 85 patients were admitted to the critical care center each month. This Study was approved by the medical ethics review committee of NHO Kure Medical Center and Chugoku Cancer Center (receipt number: 2022 - 44). EMTs from the surrounding area must treat the patient according to their condition according to pre-determined protocols. EMTs from the surrounding area will provide pre-hospital treatment depending on the patient's condition, following pre-determined protocols. The protocol includes administering adrenaline in the event of cardiac arrest, defibrillation in the event of a defibrillation-eligible rhythm, administration of glucose in the event of hypoglycemia, and administration of oxygen for hypoxia. Subjects were given the opportunity to refuse to participate in the study by opting out. The report adheres to the Strengthening the Reporting of Observational Studies in Epidemiology statement.

3. Participants

The subjects were patients who were transported to the ED between April 1to December 31 in 2021. We excluded pediatric patients (under 18 years old), pregnant women, COVID-19 patients, patients transported by medical helicopter, and patients who had cardiac arrest in the prehospital setting. This is because of differences in patient factors and management techniques [15, 16]. In addition, patients who left the critical care center within 24 hours of admission (excluding cases of death) and patients who were admitted to the critical care center due to reasons such as the time when the psychiatrist was not available were excluded. This is because the patient could have entered the hospital regardless of the severity. Furthermore, for patients who were transported multiple times during the study period, only the first emergency transport was included, and patients with missing data concerning vital signs and those who requested not to participate in the study were excluded.

4. Data Collection and Variable Definitions

The data on demographic and clinical characteristics of the subjects' age, gender, diagnosis at admission, and outcome (death within 24 hours after admission, presence of sudden illness, transfer to general ward, discharge) were collected from electronic medical records. For the subjects' physical conditions we referred to previous research to choose factors to be used in this study [17, 18]. The vital signs at the time of contact with EMTs, such as respiratory rate, percutaneous arterial oxygen saturation (SpO_2), oxygen administration, heart rate, blood pressure, and Glasgow Coma Scale (GCS) total score, body temperature, and the count of signs of shock were obtained from the emergency transport forms stored in the electronic medical record. The fraction of inspired oxygen (FiO_2) was used for the amount of oxygen administered. The oxygen concentration in normal air is $FiO_2 = 0.21$, and the FiO_2 administered by each device was based on previous research: nasal cannula at 1-4 L/min (FiO_2 = 0.24-0.35), face mask at 5-10 L/min (FiO_2 = 0.35-0.55), and the reservoir mask at 10-15 L/min (FiO_2 = 0.8-0.95), respectively. Respiratory symptoms (difficulty breathing, cough, sputum production, wheezing, cyanosis), signs of shock (respiratory failure, weak pulse, cyanosis, damp and cold skin), diagnosis on admission (respiratory disease, heart disease, neurological disease, gastrointestinal disease, trauma, and other illnesses) were selected based on previous research [19]. The count of signs of shock (the corresponding count of signs of shock exhibited by patients in the prehospital setting) was investigated based on previous research [12]. Respiratory failure was defined as a SpO_2 of less than 90%, and dyspnea was defined as a patient exhibiting symptoms of dyspnea.

4.1 Outcome

The outcome was to identify factors (vital signs, respiratory symptoms, signs of shock) that can be used to predict admissions to thecritical care center during emergency transport.

4.2 Statistical Analyses

The data representation methods were median (IQR) for continuous variables, and number and percentage (%) for categorical variables. The Shapiro-Wilk test was performed to confirm normality. In this study, univariate and multivariate logistic regression analyses were performed to clarify the factors (vital signs, signs of shock, and respiratory symptoms) that predict admission to thecritical care center.

In the univariate analysis, admission to the critical care center was used as the objective variable, and in addition to respiratory symptoms and signs of shock, vital signs such as pulse rate, mean blood pressure(MBP), Sum GCS, and body temperature were used as explanatory variables. The classification was based on APACHE II and SpO_2/FiO_2 [18, 20]. The classification of each vital sign was as follows:the respiratory rate was divided into 4 categories (less than 10 breaths/min, 10-11 breaths/min, 12-24 breaths/min, 25-34 breaths/min, and 35 breaths/min or more); SpO_2/FiO_2 was divided into 4 categories (less than 100, 100-200, 200-300, 301 or more); GCS was divided into 5 categories (3-5 points, 6-8 points, 9-10 points, 11-13 points, 14-15 points); temperature was divided into 5 categories (39°C or higher, 38.5-38.9°C, 36-38.4°C, 34.1-35.9°C, 34°C or lower); pulse rate was divided into 5 categories (140 beats/min or more, 139 to 110 beats/min, 109 to 70 beats/min, 69 to 55 beats/min, and 54 beats/min or less); and MBP was divided into six categories (160 mmHg or higher, 159 to 130 mmHg, 129 to 110 mmHg, 109 to 70 mmHg, 69 to 50 mmHg, and 50 mmHg or lower). These vital sign categories and the patient's symptoms were used as covariates [17, 19]. In the multivariate analysis, the Variance Inflation Factor (VIF) was used to check for multicollinearity between covariates. Considering the possibility of multicollinearity, each vital sign itself, respiratory symptoms, and signs of shock were used as a covariate. We used age, heart rate, MBP, body temperature, and respiratory rate as squared terms. The squared terms were used to capture the nonlinear relationship between the explanatory variable and the objective variable [17]. In this study, the significance test was two-tailed, and the p-value of 5% was used to determine the significance. Statistical analysis software R version 4.2.2 (R foundation for statistical computing) was used for statistical analyses.

5. Results

5.1 Patient Characteristics

The study subjects were 2,353 patients transported by ambulance. Of these, 1,685 patients who did not meet the exclusion criteria or with nomissing data were analyzed (Figure 1). Patient characteristics are shown in Table 1. The median age was 77.0 years (IQR 66.0 - 85.0), and there were no significant differences in gender (male 52.3%, female 47.7%). The diseases of patients admitted to the critical care center were neurological in 20.3% of the patients, gastrointestinal in 26.0%, and trauma in 12.3%. Focusing on the vital signs of patients admitted to the critical care center, the median respiratory rate was 24.0 bpm (IQR 18.0 - 30.0) which was higher than in other groups and SpO_2/FiO_2 was lower compared to other groups, with a median value of 440.5 (IQR 228.1- 461.9). Focusing on respiratory symptoms, the prevalence of feeling of dyspnea was significantly higher at 44.3%. Furthermore, focusing on shock symptoms among patients admitted to the critical care center, 42.3% had no symptoms, 20.3% had 1 symptom, 18.9% had 2 symptoms, 16.0% had 3 symptoms, and 2.6% had 4 symptoms. The breakdown of the types of shock symptoms was respiratory failure in 37.7%, wet and cold skin in 31.1%, cyanosis in 29.7%, and weak pulse in 17.7%. Although shock symptoms were supposed to be marked on the emergency transport form if observed, 240 cases of shock symptoms were not recorded.

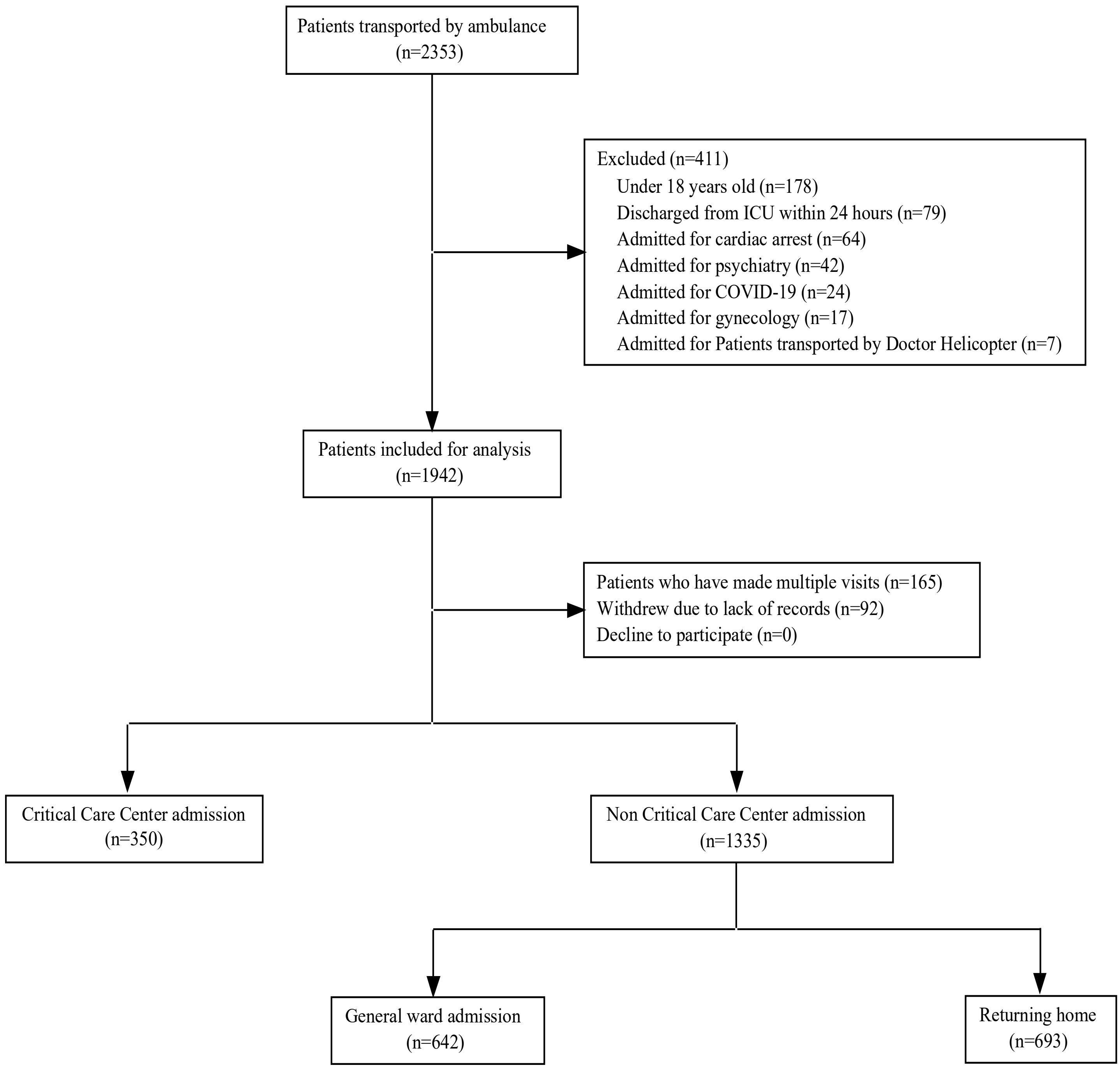

Figure 1: Flow Diagram Outlining the Screening and Enrollment of Participants. COVID-19, Coronavirus Disease 2019

Characteristics	Overall, n = 1,685	Critical Care Center admission n = 350	Non Critical Care Center admission n = 1,335	
			General ward admission n = 642	Returning home n = 693
Age (years), median (IQR)	78.0 (66.0, 85.0)	77.0 (66.0, 85.0)	75.0 (56.0, 84.0)	80.0 (72.0, 87.0)
Sex (Male), n (%)	881 (52.3)	191 (54.6)	334 (52.0)	356 (51.4)
Diagnosis, n (%)				
Trauma	367 (21.8)	43 (12.3)	206 (32.1)	118 (17.0)
Neurology	220 (13.1)	71 (20.3)	40 (6.2)	109 (15.7)
Gastroenterology	212 (12.6)	38 (10.9)	29 (4.5)	145 (20.9)
Cardiology	176 (10.4)	91 (26.0)	39 (6.1)	46 (6.6)
Respiratory medicine	158 (9.4)	32 (9.1)	26 (4.0)	100 (14.4)
Nephrology and Urology	69 (4.1)	9 (2.6)	16 (2.5)	44 (6.3)
Others	483 (28.7)	66 (18.9)	286 (44.5)	131 (18.9)
Heart rate (bpm), median (IQR)	87.0 (74.0, 101.0)	91.0 (77.0, 110.0)	83.0 (72.0, 98.0)	88.0 (76.0, 102.0)
MAP (mmHg), median (IQR)	100.3 (86.7, 115.0)	98.5 (79.1, 115.7)	103.0 (90.0, 117.3)	98.7 (86.7, 112.0)
Sum GCS, median (IQR)	15.0 (14.0, 15.0)	14.0 (12.0, 15.0)	15.0 (14.0, 15.0)	15.0 (14.0, 15.0)
Temperature (℃), median (IQR)	36.7 (36.2, 37.1)	36.6 (36.1, 37.1)	36.6 (36.2, 36.9)	36.8 (36.4, 37.4)
Respiratory rate (bpm), median (IQR)	20.0 (18.0, 24.0)	24.0 (18.0, 30.0)	20.0 (18.0, 24.0)	20.0 (18.0, 24.0)
SpO_2/FiO_2, median (IQR)	457.1 (433.3, 466.7)	440.5 (228.1, 461.9)	466.7 (457.1, 471.4)	457.1 (428.6, 466.7)
Clinical symptoms, n (%)				
Dyspnea	332 (19.7)	155 (44.3)	55 (8.6)	122 (17.6)
Coughing	32 (1.9)	9 (2.6)	5 (0.8)	18 (2.6)
Expectoration	47 (2.8)	18 (5.1)	8 (1.2)	21 (3.0)
Stridor	33 (2.0)	16 (4.6)	7 (1.1)	10 (1.4)
Cyanosis	148 (8.8)	104 (29.7)	11 (1.7)	33 (4.8)
Respiratory failure	231 (13.7)	132 (37.7)	21 (3.3)	78 (11.3)
Skin wetness or coldness	186 (11.0)	109 (31.1)	26 (4.0)	51 (7.4)
Pulse weakness	81 (4.8)	62 (17.7)	6 (0.9)	13 (1.9)
Count of signs of shock, n (%)				
0	1,303 (77.3)	148 (42.3)	592 (92.2)	563 (81.2)
1	203 (12.0)	71 (20.3)	39 (6.1)	93 (13.4)
2	104 (6.2)	66 (18.9)	8 (1.2)	30 (4.3)
3	65 (3.9)	56 (16.0)	3 (0.5)	6 (0.9)
4	10 (0.6)	9 (2.6)	0 (0.0)	1 (0.1)

Continuous variables were presented as means (standard deviations) for those for which a normal distribution could be assumed and presented as medians (interquartile range) for those for which no such distribution could be assumed. categorical variables were presented as numbers (%). APACHE II score, acute physiology and chronic health evaluation II score; MBP, Mean blood pressure; IQR, interquartile range.

Table 1: Baseline Demographic and Clinical Characteristics of Critical Care and Non-Critical Care Center

5.2 Outcome

The results of the evaluation items and the univariate analysis are shown in Figure 2. There was a statistically significant association between respiratory rate and admission to the critical care center (unadjusted OR 1.06, [95% CI 1.04-1.08], $p < 0.001$). We found that an increased count of signs of shock was associated with an increased unadjusted OR for admission to critical care centers.

Variables	Critical Care Center admission	Non Critical Care Center admission	Unadjusted Odds Ratio (95% CI)	P/Value
Age (years)	77.0 (73.5 - 77.0)	78.0 (75.0 - 76.5)	1.00 (1.00 - 1.01)	0.448
Sex (Male)	54.6 (49.2 - 59.8)	51.7 (49.0 - 54.4)	1.12 (0.89 - 1.42)	0.336
Heart rate (bpm)	91.0 (90.5 - 95.5)	86.0 (85.5 - 88.0)	1.01 (1.01 - 1.02)	<0.001
≧140	4.3 (2.51 - 7.12)	1.6 (1.06 - 2.53)	2.67 (1.35 - 5.17)	0.004
110 - 139	22.3 (18.1 - 27.1)	11.5 (9.83 - 13.3)	2.22 (1.63 - 2.99)	<0.001
70 - 109	58.6 (53.2 - 63.8)	69.2 (66.6 - 71.7)	0.63 (0.49 - 0.80)	<0.001
55 - 69	11.4 (8.38 - 15.3)	15.8 (13.9 - 17.9)	0.69 (0.47 - 0.98)	0.042
<55	3.4 (1.87 - 6.07)	1.9 (1.24 - 2.79)	1.86 (0.89 - 3.67)	0.082
MBP (mmHg)	98.5 (95.2 - 101.0)	101.0 (100.2 - 102.3)	1.00 (0.99 - 1.00)	0.054
≧130	14.0 (10.6 - 18.2)	8.6 (7.19 - 10.3)	1.73 (1.20 - 2.45)	0.003
110 - 129	18.9 (15.0 - 23.4)	23.7 (21.5 - 26.1)	0.75 (0.55 - 1.00)	0.053
70 - 109	52.0 (46.6 - 57.3)	63.1 (60.4 - 65.7)	0.63 (0.50 - 0.80)	<0.001
50 - 69	13.1 (9.87 - 17.2)	4.4 (3.41 - 5.70)	3.27 (2.17 - 4.90)	<0.001
<50	2.0 (0.88 - 4.26)	0.1 (0.03 - 0.60)	13.60 (3.27 - 91.60)	0.001
Sum GCS	14.0 (13.5 - 14.0)	15.0 (14.5 - 14.5)	0.84 (0.80 - 0.88)	<0.001
14 - 15	67.4 (62.2 - 72.3)	85.8 (83.8 - 87.6)	0.34 (0.26 - 0.45)	<0.001
11 - 13	16.9 (13.2 - 21.3)	8.8 (7.33 - 10.4)	2.11 (1.50 - 2.95)	<0.001
9 - 10	3.4 (1.87 - 6.07)	2.1 (1.42 - 3.06)	1.66 (0.80 - 3.22)	0.149
6 - 8	4.9 (2.94 - 7.81)	1.6 (1.06 - 2.53)	3.05 (1.58 - 5.78)	<0.001
3 - 5	7.4 (5.00 - 10.8)	1.6 (1.06 - 2.53)	4.79 (2.68 - 8.63)	<0.001
Temperature(°C)	36.6 (36.5 - 36.7)	36.7 (36.7 - 36.7)	0.91 (0.81 - 1.02)	0.109
≧39	5.1 (3.17 - 8.15)	3.9 (2.95 - 5.11)	1.34 (0.75 - 2.27)	0.299
38.5 - 38.9	2.6 (1.26 - 5.00)	2.7 (1.92 - 3.75)	0.95 (0.43 - 1.91)	0.897
36 - 38.4	74.0 (69.0 - 78.5)	80.5 (78.3 - 82.6)	0.69 (0.52 - 0.91)	0.008
34 - 35.9	15.7 (12.1 - 20.1)	12.4 (10.7 - 14.4)	1.31 (0.94 - 1.82)	0.106
≦33.9	2.6 (1.26 - 5.00)	0.4 (0.18 - 1.03)	5.85 (2.09 - 17.50)	<0.001
Respiratory rate (bpm)	24.0 (23.0 - 24.0)	20.0 (21.0 - 21.0)	1.06 (1.04 - 1.08)	<0.001
≧35	12.0 (8.88 - 16.0)	4.6 (3.61 - 5.95)	2.80 (1.85 - 4.21)	<0.001
25 - 34	21.7 (17.6 - 26.5)	9.9 (8.37 - 11.6)	2.53 (1.85 - 3.44)	<0.001
12 - 24	65.1 (59.9 - 70.1)	85.4 (83.4 - 87.2)	0.32 (0.24 - 0.42)	<0.001
≦11	1.1 (0.37, 3.10)	0.1 (<0.01, 0.49)	15.40 (2.27 - 302.00)	0.015
SpO_2/FiO_2	440.5 (314.8 - 370.9)	461.9 (457.1 - 459.5)	0.99 (0.99 - 0.99)	<0.001
>300	65.4 (60.2 - 70.4)	91.8 (90.1 - 93.2)	0.17 (0.13 - 0.23)	<0.001
200 - 300	10.3 (7.40 - 14.1)	5.0 (3.94 - 6.37)	2.17 (1.41 - 3.29)	<0.001
100 - 200	7.4 (5.00 - 10.8)	1.5 (0.94 - 2.35)	5.28 (2.92 - 9.68)	<0.001
<100	16.9 (13.2 - 21.3)	1.7 (1.12 - 2.62)	11.60 (7.12 - 19.40)	<0.001
Clinical symptoms				
Dyspnea	44.3 (39.0 - 49.7)	13.3 (11.5 - 15.2)	5.20 (4.00 - 6.77)	<0.001
Coughing	2.6 (1.26 - 5.00)	1.7 (1.12 - 2.62)	1.51 (0.65 - 3.18)	0.304
Expectoration	5.1 (3.17 - 8.15)	2.2 (1.49 - 3.15)	2.44 (1.32 - 4.41)	0.004
Stridor	4.6 (2.72 - 7.47)	1.3 (0.77 - 2.08)	3.71 (1.84 - 7.46)	<0.001
Cyanosis	29.7 (25.0 - 34.8)	3.3 (2.43 - 4.44)	12.40 (8.56 - 18.30)	<0.001
Respiratory failure	37.7 (32.7 - 43.0)	7.4 (6.09 - 8.99)	7.56 (5.62 - 10.20)	<0.001
Skin wetting or coldness	31.1 (26.4 - 36.3)	5.8 (4.61 - 7.19)	7.39 (5.36 - 10.20)	<0.001
Pulse weakness	17.7 (13.9 - 22.2)	1.4 (0.88 - 2.26)	14.90 (8.95 - 26.00)	<0.001
Count of shock signs				
0	42.3 (37.1 - 47.7)	86.5 (84.5 - 88.3)	0.11 (0.09 - 0.15)	<0.001
1	20.3 (16.3 - 25.0)	9.9 (8.37 - 11.6)	2.32 (1.68 - 3.17)	<0.001
2	18.9 (15.0 - 23.4)	2.8 (2.05 - 3.93)	7.93 (5.24 - 12.20)	<0.001
3	16.0 (12.4 - 20.4)	0.7 (0.33 - 1.32)	28.10 (14.40 - 61.40)	<0.001
4	2.6 (1.26 - 5.00)	0.1 (<0.01 - 0.49)	35.20 (6.58 - 650.00)	<0.001

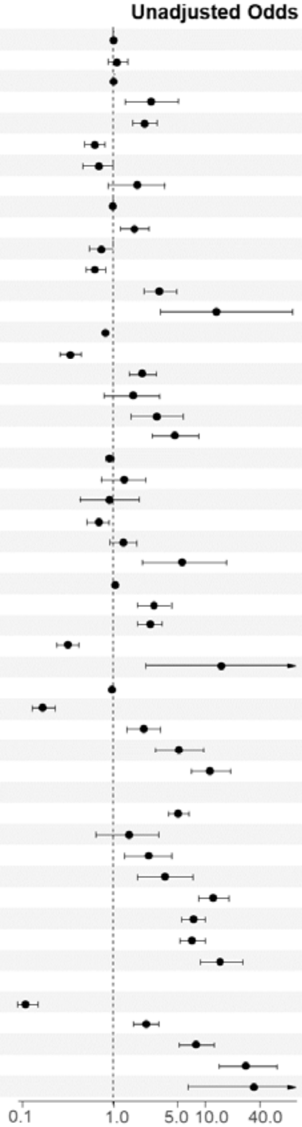

Figure 2: Association of Prehospital Vital Signs and Patient Signs with Critical Care Center Admission: Univariate Analysis

The horizontal bars represent 95% confidence intervals. Covariates included collaborative age (years), sex(men), heart rate (bpm), MAP(mmHg), sum GCS, temperature(°C), Respiratory rate (bpm), SpO_2/FiO_2, clinical symptoms, and count of signs of shock. Covariates were set at cutoff values using APACHE II score. APACHE II Score, Acute Physiology and Chronic Health Assessment II Score; CI, confidence interval; OR, odds ratio; MAP, Mean arterial pressure; GCS, Glasgow coma scale.

The results of the multivariate analysis are shown in Figure 3. GCS total score was statistically significantly associated with admission to the critical care center (adjusted OR 0.92, [95% CI 0.87-0.97], $p = 0.001$). Moreover, the odds ratio of admission to the critical care center increased when symptoms of cyanosis, wet and cold skin, and weak pulse appeared (adjusted OR 2.93, [95% CI 1.75-4.92], $p < 0.001$; adjusted OR 3.87, [95% CI 2.63-5.67], $p < 0.001$; adjusted OR 9.57, [95% CI 5.18-18.3], $p < 0.001$, respectively). Other variables were not significantly associated with the critical care centeradmission. In this regression model, all VIFs were less than 5.0, the average VIF was less than 1.5, and there was no multicollinearity (Additional file 1: Table S1).

Variables	Critical Care Center admission	Non Critical Care Center admission	Adjusted Odds Ratio (95% CI)	P/Value
Age^2	5,929.0 (5,540.0 - 6,008.5)	6,084.0 (5,700.5 - 5,945.0)	1.00 (1.00, 1.00)	0.096
Sex (Male)	54.6 (49.2 - 59.8)	51,7 (49.0 - 54.4)	1.04 (0.78, 1.37)	0.803
Heart rate^2	8,281.0 (8,428.5 - 9,462.5)	7,396.0 (7,514.0 - 7,896.5)	1.00 (1.00, 1.00)	0.194
MBP^2	9,702.3 (9,372.1 - 10,565.3)	10,201.0 (10,219.5 - 10,671.9)	1.00 (1.00, 1.00)	0.001
Sum GCS	14.0 (13.5 - 14.0)	15.0 (14.5 - 14.5)	0.92 (0.87, 0.97)	0.001
Temperature^2	1,339.6 (1,336.0 - 1,350.6)	1,346.9 (1,343.5 - 1,350.6)	1.00 (1.00, 1.00)	0.359
Respiratory rate^2	576.0 (576.0 - 640.0)	400.0 (450.0 - 450.0)	1.00 (1.00, 1.00)	0.566
SpO_2 /FiO_2	440.5 (314.8 - 370.9)	461.9 (457.1 - 459.5)	1.00 (1.00, 1.00)	0.612
Clinical symptoms				
Dyspnea	44.3 (39.0 - 49.7)	13.3 (11.5 - 15.2)	1.40 (0.82, 2.32)	0.209
Coughing	2.6 (1.26 - 5.00)	1.7 (1.12 - 2.62)	0.71 (0.26, 1.84)	0.499
Expectoration	5.1 (3.17 - 8.15)	2.2 (1.49 - 3.15)	1.43 (0.67, 3.01)	0.35
Stridor	4.6 (2.72 - 7.47)	1.3 (0.77 - 2.08)	1.68 (0.69, 3.99)	0.248
Respiratory failure	37.7 (32.7 - 43.0)	7.4 (6.09 - 8.99)	1.73 (0.88, 3.42)	0.111
Cyanosis	29.7 (25.0 - 34.8)	3.3 (2.43 - 4.44)	2.93 (1.75, 4.92)	<0.001
Skin wetness or coldness	31.1 (26.4 - 36.0)	5.8 (4.61 - 7.19)	3.87 (2.63, 5.67)	<0.001
Pulse weakness	17.7 (13.9 - 22.2)	1.4 (0.88 - 2.26)	9.57 (5.18, 18.30)	<0.001

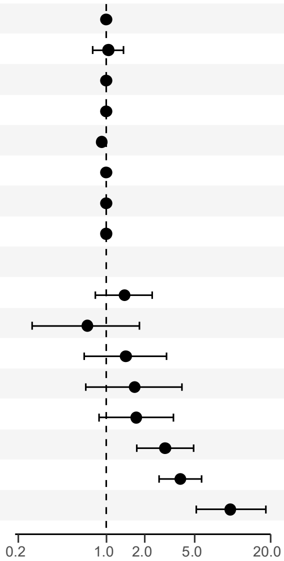

Figure 3: Association of Prehospital Vital Signs and Patient Signs with Critical Care Center Admission: Multivariable Analysis

Horizontal bars represent 95% confidence intervals. Squared terms were used for covariates with nonlinear relationships. Covariates included collaborative age^2, sex(men), heart rate^2, MAP^2, sum GCS, temperature^2, Respiratory rate^2, SpO_2/FiO_2, and clinical symptoms. CI, confidence interval; OR, odds ratio; MAP, Mean arterial pressure; GCS, Glasgow coma scale.

6. Discussion

As a result of the multivariate analysis in this study, the vital signs that were found to be most closely associated with admission to critical care centers were GCS, symptoms of shock such as cyanosis, wet and cold skin, and weak pulse, all of which showed a statistically significant association with admission to critical care centers.

Previous studies have concluded that GCS is the most important factor for predicting ICU admission or in-hospital death in acute patients who pass through the ED, and the present study had similar results [21-23]. It had been reported that "changes in the level of consciousness increase the risk of ICU admission by 77%", and a significant association has been shown between the level of consciousness and the risk of death [24, 17]. The main factors for multiple diseases associated with a declininglevel of consciousness were respiratory diseases in 39% of all patients and metabolic diseases in 44%, respectively. In addition to symptoms occurring the hour before cardiac arrest, 70% of all patientswho experienced cardiac arrest had decreased respiratory function or level of consciousness within the previous 8 hours [25]. Furthermore, one observational study stated that "Between the field and the ED, the parameter demonstrating the highest level of agreement was GCS.", and "Prehospital PP and RR were poorly predictive of ED measurements [26]". Considering this correlation, prehospital GCS information is important in predicting patient prognosis.

A previous studyconcluded that not only the types of vital signs showing abnormal values but also the number of vital signs showing abnormal values are important in predicting ICU admission and in-hospital mortality [12]. The results of the univariate analysis of this study showed that as the count of signs of shock (0 to 4) increased, the odds ratio of admission to the critical care center increased. This suggests that there is a statistically significant relationship. In medical practice, amalgamations of vital signs, indicators of shock, and physical manifestations are occasionally employed concomitantly to evaluate the health status of a patient. However, these variables do not invariably align and might manifest distinct physical symptoms contingent upon the specific ailment or preexisting health condition experienced by the individual. Therefore, an increase in the number of abnormal vital signs and an increase in the count of signs of shock in patients may be associated with the deterioration of the patient's condition; however, they are not synonymous.

Previous studies have not yet investigated the significance of observing signs of shock in prehospital settings. In general,"A severe mismatch between the supply and demand of oxygen is the common feature of all types of shock. [27]". Furthermore,there have been many previous studies aimed at capturing the state of shock and predicting triage, mortality, and ICU admission for critically ill patients [28, 29]. From this, it is natural that it is necessary to detect early on whether or not the patient is in shock during the acute stage. However, the presence or absence of shock symptoms is not confirmed in all prehospital cases. This is because the usefulness of observing signs of shock has not yet been clarified. Shock is an acute, life-threatening syndrome in which blood flow to important organs cannot be maintained as a result of an invasion of the living organism or of a biological reaction to the invasion, resulting in cellular metabolic disorders or organ damage. Although vital signs cannot be seen unless a monitoring device is worn, monitoring for signs of shock can be done quickly and easily. Furthermore, within the prehospital milieu, expeditious discernment of severity and urgency is imperative, necessitating rapid judgment. In response to this fact, observation of signs of shock can be confirmed before EMTs place the patient in the ambulance and attach the monitor. It is possible to predict the need for admission to EDs and the need for abundant human resources and materials. Furthermore, since this study found a relationship between signs of shock and admission to the critical care center, observation of shock symptoms can be useful in MC and hotlines. Currently, there is a movement in various parts of Japan to use tablet PCs to transmit emergency case information, create activity record sheets, and link to statistical systems. In Hiroshima Prefecture, which includes the Kure secondary medical area, a demonstration experiment will begin in 2024 to allow pre-hospitalization records entered by EMTs to be viewed on hospital terminals. The system allows emergency services and the receiving hospital to share information through a screen before the patient arrives at the hospital. In the demonstration experiment, vital signs such as consciousness level and SpO_2 can be entered individually, but signs of shock can only be described in text. Therewill be variations in the free description of shock symptoms. In the future, it is thought that prehospital records will mainly be sent electronically, so it is thought that it will be necessary to consider how to record shock symptoms.

In prior studies, respiratory rate and SpO_2 have been identified as significant predictors of in-hospital cardiac arrest, mortality, and abrupt patient deterioration [11, 12, 30]. However, in our study, the respiratory rate did not attain statistical significance as a predictor for admission to the critical care center, diverging from findings in previous research indicating an elevated respiratory rate as a robust indicator of acute illness and pain [12, 30]. Their previous research focused on ED and in-hospital management, and we believe that the discrepancy is due to the different situational settings. One of the reasons for this is that there has been no analysis of the time required fromthe emergency team's arrival at the scene to the hospital and also to the final destination. Furthermore, our study revealed that SpO_2/FiO_2 did not achieve statistical significance as a predictor of critical care center admissions. This differs from previous studies in which SpO_2 was thought to be important. Our study included SpO_2/FiO_2 to reflect the results of multiple studies showing that it may be a reliable marker of impaired oxygenation [17, 20, 31-33]. The FiO_2 has been shown to directly influence physiological variables measured during oxygen administration, especially the SpO_2 [34]. Thus, we posit that antecedent investigations may have omitted the collection of data on oxygen administration and possibly failed to consider pertinent patient physiological variables. No study has reported that respiratory symptoms in the prehospital setting predict admission to a critical care center. The results of this study showed that there were no statistically significant predictors of admission to the critical care center regarding respiratory symptoms. Previous studies have suggested that dyspnea scores based on patient assessment can be ambiguous because many subjective and emotional factors are involved [35]. This suggests that there may be a discrepancy with objective data. Additionally, Medically unexplained dyspnea (MUD) refers to a condition characterized by a sensation of dyspnea and is typically applied to patients presenting with anxiety and hyperventilation without cardiopulmonary explanations for their dyspnea [36]". It is possible that such patients were present in this study although there is no way to determine this. On the other hand, cyanosis was the only respiratory symptom in this study that was shown to be statistically significant. Cyanosis is a condition in which the skin and mucous membranes turn blue-purple due to decreased oxygen supply or poor circulation in the bloodand it is included as a sign of shock. Therefore, there was a statistically significant relationship between signs of shock and cyanosis, which is a common respiratory symptom. Additionally, cyanosis is typically considered a physical symptom that occurs when a patient's oxygen saturation drops below 85% and is easily observed by EMTs. Therefore, we consider it useful to report on in the prehospital setting.

We acknowledge that this study has several limitations. First, our study was a single-center retrospective observational study with 1,985 patients. The results of univariate analysis (FIG. 2) revealed that CI shows a wide range when the mean blood pressure is less than 50 mmHg. Similarly, the incidence of respiratory rate <11 bpm and four signs of shock was 0.1%. The low incidence of each was thought to be a common cause. For these reasons, large-scale multicenter studies should be conducted to increase the reliability of the results.

Second, confounding factors other than the covariates included in the multivariate analysis may have an effect. In particular, regional differences in the intervention or not by EMTs, training, and prehospital protocols must be considered. Expanding the study to include multiple centers from different geographic areas could help generalize the findings and validate the predictive power of the identified prehospital factors across a broader resion. In addition, because this study used electronic medical records and emergency transport forms, the possibility of unrecorded information and under-observation must be considered.Vital signs were omitted in 92 instances, and these were subsequently excluded as missing data. There were also 240 cases in which signs of shock were omitted, although they were not treated as missing data. For these reasons, it is desirable to conduct prospective multicenter studies in which confounding factors and covariates are fully considered. In subsequent endeavors, it is imperative to strive for enhancements, encompassing collaborative efforts and educational initiatives among neighboring emergency services, along with the refinement of emergency transport documentation grounded in evidence.

7. Conclusions

In this study, the level of consciousness and signs of shock were found to be associated with admission to the critical care center. It is believed that on-site judgment using these will assist in appropriate MC.

Data Availability Statement

Materials generated in this study are available from the corresponding author upon request.

Acknowledgements
This study complies with the Declaration of Helsinki, and all ethics committees at each site waived informed consent. Those with specific reference numbers are: Tokyo health care university, Japan ethics approval 022-05; The NHO Kure Medical Center and Chugoku Cancer Center, Japan ethics approval 2022-44. We thank the participating the educate school and hospitals for their time and effort in gathering the data for this study.

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