—**Original**—

On-Scene Time and Outcomes in Patients with Out-of-Hospital Cardiac Arrest and Return of Spontaneous Circulation at the Scene: A Post-Hoc Analysis of a Multicenter Cohort Study

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Background: The optimal on-scene time after the return of spontaneous circulation (ROSC) following out-of-hospital cardiac arrest (OHCA) has not been established. This study aimed to investigate the relationship between the on-scene time after ROSC and neurological outcomes.

Methods: We analyzed data recorded in the SOS-KANTO 2017 registry between September 2019 and March 2021. Patients with OHCA who achieved ROSC on the scene were included and categorized into three groups based on on-scene time after ROSC (0-<6 min, 6-<10 min, and ≥10 min). Comparisons were performed using multiple propensity score analysis. The primary outcome was favorable neurological status at one month, defined as cerebral performance categories 1 and 2.

Results: In total, 331 patients were included. Favorable neurological outcomes at one month were observed in 29.1% (32/123) of patients in the 0-<6 min group, 37.2% (35/104) in the 6-<10 min group, and 36.3% (29/104) in the ≥10 min group. There was no significant association between shorter on-scene times (0-<6 min) and favorable neurological outcomes at one month compared to the other groups (adjusted odds ratio [AOR], 0.97; 95% confidence interval [CI], 0.39-2.41 for 6-<10 min; AOR, 0.90; 95% CI, 0.30-2.70 for ≥10 min).

Conclusion: Differences in on-scene time after ROSC were not significantly associated with favorable neurological outcomes at one month. Future research should focus on identifying factors that may influence outcomes, and on exploring strategies to enhance care in the Japanese EMS context.

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Key words: cardiac arrest, post-resuscitation on-scene time, out-of-hospital

Introduction

Out-of-hospital cardiac arrest (OHCA) occurs in approximately 235,000-325,000 individuals annually in the United States, 275,000 in Europe, and 120,000 in Japan[1–3]. Although the prognosis of OHCA has improved over the years, the one-month survival rate with favorable neurological outcomes remains below 10%, even for witnessed cardiac arrests of cardiac origin. Additionally, it is well-established that the longer the time to return to spontaneous circulation (ROSC), the lower the likelihood of successful resuscitation and return to normal life, making it a significant public health concern[4,5].

In the 2020 International Consensus on Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular

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Care (ECC) by the International Liaison Committee on Resuscitation, a new topic was introduced concerning the timing of leaving the scene: specifically, how long emergency medical services (EMS) should remain at the scene in OHCA cases. However, clear evidence for this has yet to be established[6,7].

Reports on on-scene time for OHCA primarily come from Western countries, where protocols emphasize providing stabilization procedures after ROSC as part of advanced life support (ALS) at the scene[8–12]. While the debate continues between "remaining on-scene" versus "early transport," Japan follows a protocol that prioritizes early transport to medical facilities, limiting on-scene interventions to only those deemed absolutely necessary[13,14]. Previous studies have suggested that for patients with OHCA who achieve ROSC at the scene, efforts to stabilize their condition at the scene are associated with improved survival rates at hospital discharge[15–17]. This may be related to the post-resuscitation interventions performed by the EMS, such as tracheal intubation and vasopressor administration.

In Japan, factors contributing to on-scene time after ROSC include not only the time required for interventions but also the assessment of the patient's condition after ROSC, the time needed to transport the patient to the ambulance, and the time required to select a medical facility. Medical facility selection is not always predetermined. The EMS team must contact hospitals directly or through the fire department's command center; if the initial hospital is unavailable, they must re-explain the patient's condition to the next-nearest hospital. If the nearest medical facility is unavailable, both on-scene and transport times are extended.

However, the effects of prolonged periods without effective intervention after ROSC remain unclear. This study aimed to investigate the relationship between on-scene time after ROSC and neurological outcomes in situations where effective interventions could not be performed.

Materials and Methods

Study Design and Setting

A post-hoc analysis of this multicenter cohort study was conducted in the Kanto region of Japan, including Tokyo and its surrounding prefectures (Tokyo, Kanagawa, Saitama, Chiba, Ibaraki, Tochigi, and Gunma). Data on patients with OHCA were prospectively collected from 42 emergency hospitals as part of the Survivors of OHCA in Kanto Area (SOS-KANTO) 2017 Study[18–20]. Of the 42 participating hospitals, 22 (52.3%) were university hospitals. The average number of beds per hospital was 672 (SD = 236), and 33 hospitals (79%) were tertiary care centers. The study period for the 2017 study was from September 2019 to March 2021. Ethical approval was obtained from the institutional review boards of all the participating medical institutions. As our analysis did not involve any personal identifying information or interventions, the requirement for informed consent was waived by the Institutional Review Board (Ethics Committee of Nippon Sport Science University).

Ethics Approval and Consent to Participate

The study protocol was approved by the Institutional Review Boards and Ethics Committees of all the participating medical institutions (approval number: 23-H126).

The requirement for informed consent was waived to ensure the patient's anonymity.

Study Participants

The study population consisted of patients with OHCA who achieved ROSC at the scene. ROSC was defined as the restoration of a palpable pulse and effective blood circulation after cardiac arrest. ROSC was further categorized into prehospital ROSC (achieved before hospital arrival) and post-hospital ROSC (achieved after hospital admission). The exclusion criteria were failure to achieve ROSC before leaving the scene, prehospital intervention by a physician via a doctor's car or helicopter, OHCA due to external causes, and cases in which the patient was not transported to the hospital.

The Emergency Medical System in Japan

In Japan's emergency medical system, when 119 emergency calls are made, an ambulance with at least one emergency medical technician (EMT) on board is dispatched to the scene. During response time, dispatchers provide verbal instructions to bystanders to encourage the administration of bystander CPR and the use of public access defibrillators. Upon arrival, the EMTs take over CPR from the bystanders and under a physician's guidance, perform advanced interventions, such as securing intravenous lines, administering adrenaline, and establishing advanced airway management, depending on specific indications, such as cardiac arrest, and the qualifications of the individual EMTs[5,21,22]. The destination hospital is determined by direct communication between the EMS team and the receiving hospital or through coordination with the Fire Department's command center, ensuring continuous communication until the appropriate hospital is confirmed[13,14] (**Supplemental Material**: https://doi.org/10.1272/jnms.JNMS.2025_92-207).

Table 1 Patient characteristics

Feature	all (n=331)	0-<6 min (n=123)	6-<10 min (n=104)	≥10 min (n=104)	p value
Age, years (SD)	67.7 (16.2)	68.9 (15.8)	66.7 (16.7)	67.3 (16.1)	0.16
Sex male, n (%)	222 (67.1)	83 (67.5)	72 (69.2)	67 (64.4)	0.19
Clinical Frailty Scale (SD)	3.4 (2.0)	4 (2.1)	3.1 (1.9)	3.5 (1.9)	0.1
Medical history, n (%)					
Myocardial infarction	26 (7.8)	12 (9.6)	9 (8.6)	5 (4.8)	0.11
Congestive heart failure	29 (8.7)	10 (8.1)	9 (8.6)	10 (9.6)	0.38
Cerebrovascular disease	22 (6.6)	5 (4.0)	7 (6.7)	10 (9.6)	0.41
Dementia	12 (3.6)	5 (4.0)	3 (2.8)	4 (3.8)	0.22
Chronic lung disease	20 (6.0)	7 (5.6)	6 (5.7)	7 (6.7)	0.41
Renal disease	17 (5.1)	5 (4.0)	4 (3.8)	8 (7.6)	0.21
Dialysis	7 (2.1)	2 (1.6)	3 (2.8)	5 (4.8)	0.08
Metastatic solid tumor	13 (3.9)	4 (3.2)	4 (3.8)	5 (4.8)	0.32
Psychiatric disorder	7 (2.1)	3 (2.4)	1 (1.0)	3 (2.8)	0.29
Witness, n (%)	202 (61.0)	73 (59.3)	64 (61.5)	65 (62.5)	0.43
Location: home, n (%)	206 (62.2)	74 (60.2)	66 (63.5)	66 (63.5)	0.38
Floor of occurrence (SD)	1.9 (2.1)	1.8 (2.1)	1.7 (1.3)	2 (2.5)	0.19
bystander CPR	175 (52.9)	59 (48.0)	60 (57.7)	56 (53.8)	0.21
PAD	31 (9.4)	8 (6.5)	11 (10.6)	12 (11.5)	0.14
Prehospital procedure by EMS, n (%)					
shockable rhythm	205 (61.9)	76 (63.9)	70 (70.0)	59 (58.4)	0.12
Intravenous Injection	145 (43.8)	68 (55.3)	41 (39.4)	36 (34.6)	<0.01
Adrenaline	108 (32.6)	58 (47.2)	32 (30.8)	18 (17.3)	<0.01
Advanced airway management	191 (57.7)	67 (54.4)	60 (57.7)	64 (61.5)	0.47
Mechanical CPR	10 (3.0)	3 (2.4)	5 (4.8)	2 (1.9)	0.23
EMS arrival to ROSC	10.5 (7.8)	10.6 (7.8)	10.5 (6.9)	9.8 (6.6)	0.35
Leaving the scene to hospital arrival	11.3 (6.3)	10.4 (5.2)	11.8 (7.2)	11.9 (6.4)	0.49

SD: standard deviation, PAD: Public Access Defibrillation, CPR: Cardio Pulmonary Resuscitation, EMS: Emergency Medical Service

Data Collection and Definitions

Information related to OHCA was prospectively collected by the EMS personnel using the Utstein template. The collected data included patient age, sex, Clinical Frailty Scale (CFS), major medical history, location of the incident, presence of a witness, bystander CPR, use of an AED, administration of defibrillation (Public Access Defibrillation, PAD), number of EMS personnel, number of EMTs, initial electrocardiogram rhythm, interventions performed (defibrillation, intravenous line establishment, adrenaline administration, advanced airway management, and use of an automated chest compression device), and time variables, including ROSC. Hospital data were collected by the attending physicians at each facility and included the patient's condition upon hospital admission, height, weight, and prognosis.

Outcomes

The primary outcome was a favorable neurological outcome at one month. Secondary outcomes included the one-month survival rate and occurrence of re-arrest before hospital arrival.

Neurological outcomes were assessed using the Cerebral Performance Category (CPC) scale, which is defined as follows: CPC 1: good cerebral performance, CPC 2: moderate disability, CPC 3: severe disability, CPC 4: vegetative state or coma, and CPC 5: brain death or death. CPC 1 and 2 were classified as favorable neurological outcomes.

Statistical Analysis

The time from ROSC to departure from the scene was defined as the on-scene time after ROSC, and patients were categorized into three groups for comparison based on this duration (0-<6 min, 6-<10 min, and ≥10 min).

Continuous variables were expressed as mean (standard deviation), and categorical variables were expressed as frequencies and percentages. To reduce bias due to missing data, multiple imputations were performed, generating five imputed datasets for the analysis[23]. Multiple imputations using fully conditional specifications were conducted for all covariates listed in **Table 1**. Multiple propensity scores were calculated using a logistic regression model to estimate the probability of being assigned

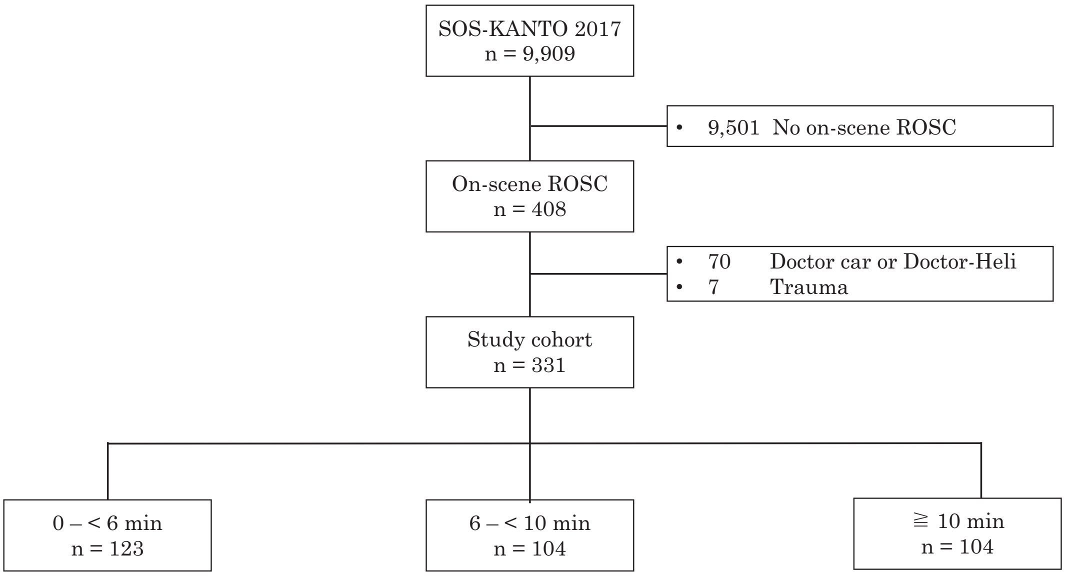

Fig. 1 Patient flow diagram
ROSC: return of spontaneous circulation

Table 2 Univariate analysis for Outcome

	0-<6 min (n=123)	6-<10 min (n=104)	≥10 min (n= 104)	p value
Favorable neurological outcome (CPC1-2)	32 (29.1)	35 (37.2)	29 (36.3)	0.23
Intra-Transport Rearrest	33 (26.8)	27 (26.0)	34 (32.7)	0.15
Survival at 30 days	53 (44.5)	49 (48.5)	41 (45.6)	0.63

CPC: Cerebral-Performance Category

to one of the three groups based on the time from ROSC to scene departure[24,25]. The variables included in the propensity score model were age, gender, CFS, comorbidities (myocardial infarction, congestive heart failure, cerebrovascular disease, dementia, chronic lung disease, renal disease, dialysis, metastatic solid tumor, psychiatric disorder), cause of cardiac arrest, time on scene, location of cardiac arrest (home, public place, hospital/clinic, nursing home), floor of occurrence, bystander CPR, witness status (EMS personnel, other, none), initial electrocardiogram rhythm (VF/pulseless VT, PEA/asystole, other), administration of adrenaline, advanced airway management, and use of an automated chest compression device[26,27]. Generalized estimating equations (GEE) were applied to account for multiple propensity scores and adjusted for clustering within the hospital[28].

The outcomes were assessed using Pearson's chi-square test to calculate *p*-values. Statistical significance was defined as a two-sided *p*-value < 0.05. All statistical analyses were performed using SPSS version 29.0 (IBM Corp., Armonk, NY, USA).

Results

During the study period, 9,909 OHCA cases were registered in the database, of which 331 were included (**Fig. 1**). The patients were divided into three groups based on the on-scene time after ROSC (0-<6 min, 6-<10 min, and ≥10 min).

The baseline characteristics of all the patients (**Table 1**) showed a mean age of 67.7 years (SD, 16.2), with 222 males (67.1%). There were 202 cases (6-<10%) of witnessed arrest, and bystander CPR was performed in 175 cases (52.9%). The administration of adrenaline by EMS personnel was recorded in 108 patients (32.6%), and advanced airway management was performed in 191 patients (57.7%).

In the univariate analysis of outcomes (**Table 2**), favorable neurological outcomes (CPC 1-2) at one month were observed in 29.1% (32/123) of patients in the 0-<6 min group, 37.2% (35/104) in the 6-<10 min group, and 36.3% (29/104) in the ≥10 min group. The rearrest rates before hospital arrival were 26.8%, 26%, and 32.7%. The rates of one-month survival were 44.5%, 48.5%, and 45.6%, re-

Table 3 Multivariable logistic regression for Outcomes

	0-<6 min (n = 123)	6-<10 min (n = 104)	≥10 min (n = 104)
Favorable neurological outcome (CPC1-2)	Reference	0.97 (0.39-2.41)	0.90 (0.30-2.70)
Intra-Transport Rearrest, odds ratio (95% CI)	Reference	1.4 (0.65-3.59)	0.76 (0.33-1.62)
Survival at 30 days, odds ratio (95% CI)	Reference	1.05 (0.39-2.89)	1.11 (0.42-2.96)

CPC: Cerebral-Performance Category

spectively.

In the multivariable logistic regression analysis (**Table 3**), there was no significant association between the 0-<6 min group and favorable neurological outcomes (CPC 1-2) at one month compared to the 6-<10 min and ≥10 min groups (OR 0.97; 95% CI 0.39-2.41, OR 0.90; 95% CI 0.30-2.70, respectively). Similarly, there was no significant association with one-month survival (OR 1.4; 95% CI 0.65-3.59, OR 0.76; 95% CI 0.33-1.62, respectively) or re-arrest before arrival to the hospital (OR 1.05; 95% CI 0.39-2.89, OR 1.11; 95% CI 0.42-2.96, respectively).

Discussion

This study analyzed data from the SOS-KANTO 2017 registry to examine the association between on-scene time following ROSC and patient outcomes in OHCA cases in which ROSC was achieved at the scene. The findings indicated that variations in on-scene time were not significantly related to favorable neurological outcomes at one month, one-month survival, or incidence of re-arrest before hospital arrival.

Previous studies in the United States indicated that stabilizing a patient's condition after ROSC before transport is associated with increased survival to hospital discharge and reduced re-arrest before hospital arrival[15]. This is likely due to the administration of interventions that contribute to stabilization, such as securing IV or IO lines, establishing central venous (CV) access, administering antiarrhythmic drugs and vasopressors, and performing advanced airway management after ROSC. However, under the current system in Japan, emergency medical technicians (EMTs) are not permitted to establish intravenous lines or perform advanced airway management in patients with ROSC[13,14].

In the current study, no significant association was found between on-scene time after ROSC and neurological outcomes. However, these findings should be interpreted with caution. In Japan, where EMS personnel are not authorized to perform stabilizing procedures post-ROSC, shorter on-scene times are generally considered preferable. In the group with longer on-scene times after ROSC (≥10 minutes), significantly lower rates of intravenous injection and adrenaline administration were observed. This finding may partly reflect the fact that many of these patients achieved ROSC without requiring extensive interventions, suggesting potentially less severe cases. However, performing these procedures requires physician authorization via online communication, during which time EMS personnel also need to coordinate hospital availability. When such interventions are unnecessary or not advised by the online physician, additional time may be spent finding an appropriate hospital, potentially contributing to extended on-scene times. These unnecessarily prolonged on-scene times may have led to disadvantages for some patients. Grouping heterogeneous patient populations with differing clinical backgrounds together in the ≥10 minutes category may partly explain why no significant association was observed between on-scene time and outcomes.

Compared to previous studies in the United States, the rate of re-arrest during transport in Japan appears to be higher (11% vs. 26.8%, 26%, and 32.7%, respectively)[29,30]. This difference may be attributed to the Japanese protocol, which prioritizes rapid transport to the hospital over stabilizing the patient's condition at the scene after ROSC, owing to limitations on the extent to which EMS personnel are authorized to perform therapeutic interventions.

In light of our findings, it may be important to consider the potential role of post-ROSC interventions that may occur during the on-scene period. Although Japanese EMS protocols limit advanced procedures, such as intravenous line establishment and advanced airway management after ROSC, reports from other countries suggest that these interventions can stabilize patients and reduce complications during transport[8-12]. The lack of such interventions in Japan may partly explain why prolonged on-scene time does not result in improved neurological outcomes. In Japan, prolonged on-scene time may often reflect logistical delays, such as finding an appropriate receiving hospital or coordinating with medical facilities, rather than additional therapeutic efforts. These delays could increase on-scene time without providing meaningful clinical benefits. Thus, optimizing the on-scene period should not focus solely on minimizing time, but rather on identifying strategies to implement effective stabilizing interventions when appropriate. Future studies are needed to evaluate the potential benefits of enabling EMTs to perform more advanced procedures post-ROSC to improve outcomes for Japanese OHCA patients.

This study had several limitations. First, because this was an observational study, unmeasured confounding factors may have influenced the results. Although multiple propensity score analyses were used to adjust for potential confounders, there may still be variables not accounted for, such as specific EMS protocols or the experience level of EMS personnel, which could have affected the patient outcomes. Second, we were unable to examine the specific reasons for prolonged on-scene time after ROSC in the current study. Third, the selection of medical facilities in Japan, which often involves time-consuming communication between EMS teams and hospitals, may have added variability to the on-scene time, further complicating the interpretation of the results. Fourth, patients transported to hospitals not participating in the SOS-KANTO were not included in this dataset, which may have introduced a selection bias toward specific populations. This factor may not be generalizable to countries with more streamlined hospital selection processes. Future studies should explore these relationships in diverse settings to improve the generalizability of the findings.

Conclusion

In this study, on-scene time after ROSC in OHCA patients was not significantly associated with favorable neurological outcomes at one month, one-month survival, or the incidence of re-arrest prior to hospital arrival. These findings suggest that the duration of on-scene time alone may not play a decisive role in determining outcomes. Future research should focus on identifying factors that may influence outcomes, and on exploring strategies to enhance care in the Japanese EMS context.

Availability of Data and Materials: The datasets generated and analyzed in the current study are available from the corresponding author upon reasonable request.

Author contributions: Conceptualization: HN, TT, KS, NK; data curation: TT; formal analysis: HN, TT; investigation: HN, TT; methodology: HN, TT, KS, NK; project administration: TT, NK; supervision: KS, SK, RT, MK, SO, NK; visualization: HN; writing-original draft: HN; writing-review and editing: TT, KS, SK, NK, RT, MK, SO.

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References

1. Atwood C, Eisenberg MS, Herlitz J, Rea TD. Incidence of EMS-treated out-of-hospital cardiac arrest in Europe. Resuscitation [Internet]. 2005 Oct;67(1):75–80. Available from: https://www.ncbi.nlm.nih.gov/pubmed/16199289
2. Nichol G, Thomas E, Callaway CW, et al. Regional variation in out-of-hospital cardiac arrest incidence and outcome. JAMA [Internet]. 2008 Sep 24;300(12):1423–31. Available from: https://www.ncbi.nlm.nih.gov/pubmed/18812533
3. Nolan JP, Soar J, Zideman DA, et al. European Resuscitation Council Guidelines for Resuscitation 2010 Section 1. Executive summary. Resuscitation [Internet]. 2010 Oct;81 (10):1219–76. Available from: https://www.ncbi.nlm.nih.gov/pubmed/20956052
4. Matsuyama T, Kitamura T, Kiyohara K, et al. Impact of cardiopulmonary resuscitation duration on neurologically favourable outcome after out-of-hospital cardiac arrest: A population-based study in Japan. Resuscitation [Internet]. 2017 Apr;113:1–7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28109995
5. Izawa J, Iwami T, Gibo K, et al. Timing of advanced airway management by emergency medical services personnel following out-of-hospital cardiac arrest: A population-based cohort study. Resuscitation [Internet]. 2018 Jul;128: 16–23. Available from: https://www.ncbi.nlm.nih.gov/pubmed/29689354
6. Merchant RM, Topjian AA, Panchal AR, et al. Part 1: Executive summary: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation [Internet]. 2020 Oct 20;142(16_suppl_2):S337–57. Available from: https://www.ncbi.nlm.nih.gov/pubmed/33081530
7. Panchal AR, Bartos JA, Cabanas JG, et al. Part 3: Adult basic and advanced life support: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation [Internet]. 2020 Oct 20;142(16_suppl_2):S366–468. Available from: https://www.ncbi.nlm.nih.gov/pubmed/33081529
8. de Graaf C, Beesems SG, Koster RW. Time of on-scene resuscitation in out of-hospital cardiac arrest patients transported without return of spontaneous circulation. Resuscitation [Internet]. 2019 May;138:235–42. Available from: https://www.ncbi.nlm.nih.gov/pubmed/30928502
9. Poppe M, Krammel M, Clodi C, et al. Management of EMS on-scene time during advanced life support in out-of-hospital cardiac arrest: A retrospective observational trial. Eur Heart J Acute Cardiovasc Care. 2020 Nov;9(4_suppl):S82–9.
10. Rajan S, Folke F, Kragholm K, et al. Prolonged cardiopul-

monary resuscitation and outcomes after out-of-hospital cardiac arrest. Resuscitation. 2016 Aug;105:45–51.
11. Banerjee PR, Ganti L, Pepe PE, Singh A, Roka A, Vittone RA. Early on-scene management of pediatric out-of-hospital cardiac arrest can result in improved likelihood for neurologically-intact survival. Resuscitation [Internet]. 2019 Feb;135:162–7. Available from: https://www.ncbi.nlm.nih.gov/pubmed/30412719
12. Spigner MF, Benoit JL, Menegazzi JJ, McMullan JT. Prehospital protocols for post-return of spontaneous circulation are highly variable. Prehosp Emerg Care [Internet]. 2021 Mar-Apr;25(2):191–5. Available from: https://www.ncbi.nlm.nih.gov/pubmed/32286900
13. Lin CH, Ng YY, Chiang WC, et al. Variation of current protocols for managing out-of-hospital cardiac arrest in-prehospital settings among Asian countries. J Formos Med Assoc [Internet]. 2016 Aug;115(8):628–38. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26596689
14. Tanigawa K, Tanaka K. Emergency medical service systems in Japan: Past, present, and future. Resuscitation [Internet]. 2006 Jun;69(3):365–70. Available from: https://www.ncbi.nlm.nih.gov/pubmed/16740355
15. Khan L, Hutton J, Yap J, et al. The association of the post-resuscitation on-scene interval and patient outcomes after out-of-hospital cardiac arrest. Resuscitation [Internet]. 2023 Jul;188:109753. Available from: https://www.ncbi.nlm.nih.gov/pubmed/36842676
16. Grunau B, Kime N, Leroux B, et al. Association of intra-arrest transport vs continued on-scene resuscitation with survival to hospital discharge among patients with out-of-hospital cardiac arrest. JAMA [Internet]. 2020 Sep 15;324(11):1058–67. Available from: https://www.ncbi.nlm.nih.gov/pubmed/32930759
17. Ran L, Liu J, Tanaka H, Hubble MW, Hiroshi T, Huang W. Early administration of adrenaline for out-of-hospital cardiac arrest: A systematic review and meta-analysis. J Am Heart Assoc [Internet]. 2020 Jun 2;9(11):e014330. Available from: https://www.ncbi.nlm.nih.gov/pubmed/32441184
18. Kitamura N, Tagami T, Takeda M, Shinozaki K; SOS-KANTO 2017 Study Group. Changes of practice on out of hospital cardiopulmonary arrest during the COVID-19 pandemic: A cross-sectional survey of SOS-KANTO 2017 study. Ann Clin Epidemiol [Internet]. 2023 Nov 10;6(1):12–6. Available from: https://www.ncbi.nlm.nih.gov/pubmed/38605916
19. Tanaka C, Tagami T, Kaneko J, et al. Impact of the COVID-19 pandemic on prehospital and in-hospital treatment and outcomes of patients after out-of-hospital cardiac arrest: A Japanese multicenter cohort study. BMC Emerg Med [Internet]. 2024 Jan 8;24(1):12. Available from: https://www.ncbi.nlm.nih.gov/pubmed/38191311
20. Tanaka C, Tagami T, Nakayama F, et al. Changes over 7 years in temperature control treatment and outcomes after out-of-hospital cardiac arrest: A Japanese, multicenter cohort study. Ther Hypothermia Temp Manag [Internet]. 2024 Feb 22;. Available from: https://www.ncbi.nlm.nih.gov/pubmed/38386985
21. Ueta H, Tanaka H, Tanaka S, Sagisaka R, Takyu H. Quick epinephrine administration induces favorable neurological outcomes in out-of-hospital cardiac arrest patients. Am J Emerg Med [Internet]. 2017 May;35(5):676–80. Available from: https://www.ncbi.nlm.nih.gov/pubmed/28087097
22. Okubo M, Komukai S, Izawa J, et al. Sequence of epinephrine and advanced airway placement after out-of-hospital cardiac arrest. JAMA Netw Open [Internet]. 2024 Feb 5;7(2):e2356863. Available from: https://www.ncbi.nlm.nih.gov/pubmed/38372996
23. Little RJ, D'Agostino R, Cohen ML, et al. The prevention and treatment of missing data in clinical trials. N Engl J Med [Internet]. 2012 Oct 4;367(14):1355–60. Available from: https://www.ncbi.nlm.nih.gov/pubmed/23034025
24. McCaffrey DF, Griffin BA, Almirall D, Slaughter ME, Ramchand R, Burgette LF. A tutorial on propensity score estimation for multiple treatments using generalized boosted models. Stat Med [Internet]. 2013 Aug 30;32(19):3388–414. Available from: https://www.ncbi.nlm.nih.gov/pubmed/23508673
25. Otake K, Tagami T, Tanaka C, et al. Trends in isolated pelvic fracture and 30-day survival during a recent 15-year period: A nationwide study of the Japan Trauma Data Bank. J Nippon Med Sch [Internet]. 2022 Jun 28;89(3):309–15. Available from: https://www.ncbi.nlm.nih.gov/pubmed/34840215
26. Austin PC. An introduction to propensity score methods for reducing the effects of confounding in observational studies. Multivariate Behav Res [Internet]. 2011 May;46(3):399–424. Available from: https://www.ncbi.nlm.nih.gov/pubmed/21818162
27. Kitano S, Ogawa K, Igarashi Y, et al. Development of a machine learning model to predict cardiac arrest during transport of trauma patients. J Nippon Med Sch [Internet]. 2023 May 30;90(2):186–93. Available from: https://www.ncbi.nlm.nih.gov/pubmed/36823128
28. Liu J, Colditz GA. Optimal design of longitudinal data analysis using generalized estimating equation models. Biom J [Internet]. 2017 Mar;59(2):315–30. Available from: https://www.ncbi.nlm.nih.gov/pubmed/27878852
29. Lerner EB, O'Connell M, Pirrallo RG. Rearrest after prehospital resuscitation. Prehosp Emerg Care [Internet]. 2011 Jan-Mar;15(1):50–4. Available from: https://www.ncbi.nlm.nih.gov/pubmed/21054177
30. Hartke A, Mumma BE, Rittenberger JC, Callaway CW, Guyette FX. Incidence of re-arrest and critical events during prolonged transport of post-cardiac arrest patients. Resuscitation [Internet]. 2010 Aug;81(8):938–42. Available from: https://www.ncbi.nlm.nih.gov/pubmed/20483520

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