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Impacts of Emergency Medical Technician Configurations on Outcomes of Patients with Out-Of-Hospital Cardiac Arrest

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Abstract:
The role of emergency medical technicians (EMTs) in providing advanced life support (ALS) for out-of-hospital cardiac arrest (OHCA) patients is crucial, yet the optimal EMT configuration remains a topic of debate. This three-year cohort study focused on non-traumatic OHCA adults treated by ALS teams , utilizing an Utstein-style population database. The study examined the impact of the EMT-paramedic (EMT-P) ratio, defined as the proportion of EMT-Ps among on-scene EMTs, on patient outcomes. Among 1357 eligible cases, the median number of on-scene EMTs was 2, with an EMT-P ratio ranging from 50% to 100%. Multivariate analysis identified several predictors of sustained return of spontaneous circulation (ROSC), including younger age, witnessed cardiac arrest, prehospital ROSC, prehospital defibrillation, and comorbid diabetes mellitus. After adjusting for confounders, each 10% increase in the EMT-P ratio was associated with an 8% higher chance of sustained ROSC (adjusted odds ratio [aOR], 1.08; $p < 0.01$) and a 12% higher likelihood of favorable neurologic status at discharge (aOR, 1.12; $p = 0.048$). Conversely, the number of on-scene EMTs did not significantly impact outcomes. This study underscores the importance of EMT-P ratio in improving outcomes for non-traumatic OHCA adults, highlighting the potential benefits of optimizing EMT configurations.
Keywords: emergency medical technician, paramedic, out-of-hospital cardiac arrest, return of spontaneous circulation

Background:
Out-of-hospital cardiac arrest (OHCA) remains a significant global challenge, with high rates of mortality and morbidity despite advancements in resuscitation science. In the United States alone, emergency medical services (EMS) attend to approximately 176,100 OHCA cases annually. reports an average of 9815 OHCA cases per year, with 30-day and 180-day mortality rates of 75.8% and 86.0%, respectively. Early recognition of cardiac arrest, prompt activation of the emergency response system, initiation of early cardiopulmonary resuscitation (CPR), and rapid defibrillation are fundamental components of prehospital basic life support (BLS) for OHCA resuscitation. Advanced life support (ALS) interventions, including intravascular therapy and endotracheal intubation, constitute a higher level of care than BLS. However, the comparative benefits of prehospital ALS versus BLS for OHCA patients remain uncertain, with conflicting findings in the literature. (Mozaffarian et al., 2015)
Emergency medical technicians (EMTs) play a critical role as frontline healthcare providers for OHCA patients worldwide. EMT-paramedic (EMT-P) accreditation requires significantly more training hours (1280 hours) compared to EMT-intermediate (EMT-I) accreditation. EMT-Ps are trained to perform

advanced procedures such as endotracheal intubation, defibrillation, intravascular therapy, and transcutaneous pacing, which EMT-Is cannot administer. Given the varying capabilities of EMT levels, the composition and number of on-scene EMTs are essential factors influencing OHCA patient outcomes. However, there is ongoing debate regarding the impact of EMT configuration on survival rates. (Hagihara et al., 2018)

While previous studies have primarily focused on total EMT numbers, some investigations have considered both the total EMT count and the proportion of EMT-Ps as key variables. EMT-Ps, with their advanced skills and confidence in clinical tasks, may contribute uniquely to OHCA patient care. Therefore, this study aims to evaluate the impact of EMT numbers and configurations, with a specific focus on the EMT-P ratio, on the outcomes of OHCA patients. (Eschmann et al., 2010)

Materials and Methods:

Study Design

A retrospective cohort study was conducted using data from an population database. The study included nontraumatic OHCA adults (age ≥ 18 years) who activated EMS teams and were treated by ALS teams. Cardiac arrest, defined as the absence of circulation signs, was confirmed by on-scene EMTs. Exclusion criteria comprised known pregnancy, age below eighteen, irreversible signs of death, severe hypothermia, or valid do-not-attempt-resuscitate (DNAR) orders. Causes of cardiac arrest were classified as traumatic or nontraumatic based on EMS and physician judgments.

Definition of Crew Number, ALS Team, and EMT-Paramedic Ratio

A crew's size is the number of EMTs in one ambulance run (typically 2 to 4). An ALS team includes at least one EMT-P. The EMT-P ratio is the proportion of EMT-Ps among on-scene EMTs in one ambulance run.

Exposure and Outcome

Data collected included patient demographics, EMS response time, initial cardiac rhythms, prehospital care, ROSC, survival at discharge, and neurologic status. Exposures were EMT configurations (crew number, EMT-P ratio). Primary outcome: sustained (≥2 h) ROSC; secondary outcomes: any ROSC, survival at discharge, and favorable neurologic status.

Statistical Analysis

SPSS Version 20.0 was used. The EMT-P ratio was stratified into four categories: 25.0–33.3%, 50%, 66.7–75.0%, and 100%. Pearson's correlation analyzed EMT-P ratio correlations. Logistic regression identified sustained ROSC predictors. Logistic regression assessed the influence of EMT number and EMT-P ratio on outcomes after adjusting for predictors. $p < 0.05$ indicated significance.

Ethical Consideration

The study adhered to ethical standards and was approved by the Institutional Review Board at National Cheng Kung University Hospital (A-ER-105-363).

Results:

Patient Population

During the study period, 8150 patients with OHCA activated the system. A total of 4498 adults with non-traumatic OHCA were considered after excluding 83 patients below 18 years old, 966 patients with traumatic OHCA, and 2603 patients with no resuscitation attempts because of valid DNR orders or other reasons. Among them, 1357 (30.5%) patients who were treated by ALS teams were eligible for the analysis. The mean (SD) age of enrollees was 68.8 (16.4) years, and 884 (65.1%) were male. The median (IQR, range) number of on-scene EMTs and the EMT-P ratio were 2 (2–2, 2–4) persons and 50% (50–100%, 25–100%), respectively.

Clinical Predictors of Sustained ROSC

Statistically significant associations of several variables with sustained ROSC were identified, including younger adults, witnessed cardiac arrest, prehospital ROSC, prehospital defibrillation, and comorbid diabetes mellitus or heart diseases.

The Impact of Crew Number and EMT-Paramedic Ratio on Patient Outcomes

After adjusting for independent predictors, increasing the EMT-P ratio was associated with a higher chance of sustained ROSC and favorable neurologic status at discharge. However, an increased number of total on-scene EMTs or EMT-Is was not linked to better patient outcomes. Additionally, the increased number of on-scene EMT-Ps was associated with a higher chance of sustained ROSC but not linked to survival to discharge or favorable neurologic status at discharge.

Discussion

The number and proportion of EMTs on the scene for OHCA resuscitation has remained a modifiable factor linked to ROSC. Until now, the influences of the EMT configuration on outcomes of OHCA patients remain controversial. Sam A. Warren et al. and Kajino et al. both indicated that the number of EMTs was associated with survival rate and even neurological outcome in patients with OHCA, whereas Hagiwara S. et al. and Eschmann NM et al. found opposite results. In our cohort, the association of EMT number and patient outcomes, in terms of sustained ROSC, survival to discharge, and favorable neurologic status at discharge, were trivial after adjustment for all the independent predictors of sustained ROSC. (Kajino et al., 2014)

EMT-Ps are capable of administering more advanced management of OHCA patients and are more confident in performing clinical activities and tasks compared with EMT-Is. Therefore, the impact of EMT-Ps on the scene of resuscitation may not be equal to the impact of EMT-Is. J.T. Sun et al. demonstrated that a high EMT-P ratio (>50%) improved the survival rate of OHCA patients. Our study also differentiated between levels of training certification among EMTs and observed similar findings. Furthermore, we found that an increase in the EMT-P ratio by 10% increased the chance of sustained ROSC by 8% and favorable neurologic status at discharge by 12%. In brief, adequate EMT-P ratios could be a crucial component of the EMS configuration. (Sun et al., 2018)

There is a major explanation for our finding that a high EMT-P ratio resulted in improved outcomes among OHCA patients. Gold LS et al. indicated that the experience of the paramedic who performed procedures rather than the paramedic in charge was associated with the survival rate of OHCA patients. By going through more training courses, EMT-Ps usually have more skill and confidence in performing OHCA resuscitation. As one EMT-P leads the resuscitation team, the other EMT-P can execute other procedures, including intravenous catheter insertion, LMA, and provision of medication. Hence, an increasing ratio of EMT-Ps may increase the likelihood that an EMT-P will perform procedures and thereby improve the outcome of OHCA patients. (Gold and Eisenberg, 2009)

However, Bayley R et al. suggested that a two-EMT-P crew did not perform better than a single-EMT-P ambulance crew, either in interventions or completeness of resuscitation. This conclusion is in opposition to our results and does not favor the inclusion of more EMT-P members. Bayley R et al. speculated that the indefinite leadership in two-EMT-P crews may contribute to the poor performance of resuscitation. Since this study only recruited 15 crews in each configuration and was conducted in a simulated situation, further real-world data are needed. Assuming the speculation of Bayley et al. is right, indefinite leadership could also be overcome by training courses or further education. Both teamwork and leadership training have been shown to improve team performance, as emphasized by American Heart Association guideline. Therefore, indefinite leadership was not considered as an explanation in our study. (Bayley et al., 2008)

Among all EMTs, an EMT-P is authorized to perform intravenous epinephrine injection. In our cohort, a high proportion of epinephrine administration was found in the group with a high EMT-P ratio. The effect of prehospital epinephrine is still being debated, and a randomized trial involving 8014 patients comparing epinephrine with placebo showed a better rate of 30-day survival. The reason that the increasing ratio of EMT-Ps did not improve the survival rate at discharge in this trial is uncertain. Our explanation is that intravenous catheter insertion on the scene may take too much time. Perkins et al. injected either epinephrine

or placebo on the scene and found no difference in EMS time at the scene; however, we did not find a difference in the ratio of scene time, which may be modulated by better competency of EMT-Ps. (Perkins et al., 2018)

Several predictors of survival from OHCA have been identified in the literature, such as bystander CPR, electric shock therapy, ambulance response time, EMS scene time, EMS transport time, location of cardiac arrest, and adrenaline use. Although only one predictor, electric shock therapy, was evidenced as an independent determinant of sustained ROSC in our cohort, two other variables, EMS response time ≤ 6 min and indoor location of arrest, were borderline-significant predictors under the multivariate analyses. We suspect that differences in the prehospital emergency systems, such as city area, density of prehospital ALS stations and hospitals, and the number and proportion of EMT-Ps on the scene who are capable of CPR and targeted temperature management, might also have resulted in the differences. (Geri et al., 2017)

Several limitations should be considered when interpreting our findings. First, as a retrospective cohort study, this study had inherent problems with data collection. Although we had undergone quality control of CPR in the fire department by the national standard training program, it is difficult to calculate the individual difference in CPR operation between EMTs. Second, the different impact of on-scene numbers of EMT-Ps and EMT-Is on patient outcome was respectively studied, but the difference between EMT-1 and EMT-2 was not considered. Additionally, although we observed better outcomes when there was a high EMT-P ratio on the scene, the different dispatcher systems or EMS teams may have different outcomes. Third, compared to the previously established report in US and Canada, less EMT numbers in the ambulance, in which the majority of cases was transported by 2 EMTs, was exhibited in our cohort. Therefore, the difficulty of external validation of our finding to other communities should be considered. Fourth, given that resuscitation skill has declined as time passed, exposure to OHCA treatment had become an important contributing factor. Previous studies suggested that recent exposure instead of career experience increased patient survival, which should be considered in future studies. Finally, the application of our study results should be tailored to local EMS practices since this study was conducted in an EMS system that adapts the policy of "resuscitation during transportation" for OHCAs. (O'Keeffe et al., 2011)

Conclusions

Despite the neglected relationship between EMT number and patient outcomes, an increase in the EMT-P ratio resulted in an increased proportion of sustained ROSC and improved cerebral performance at discharge for nontraumatic OHCA adults transported by ALS teams. Accordingly, more EMT-P training programs are needed to augment the EMT-P number and thereby raise their on-scene ratio.

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