Emergency Medical Services Equipment Use in the Emergency Department and Time to Care for Those With Out-of-Hospital Cardiac Arrest

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Study hypothesis: Early defibrillation is crucial in improving out-of-hospital cardiac arrest (OHCA) survival. The use of emergency medical services (EMS) equipment is associated with shorter time to first emergency department (ED) rhythm analysis/defibrillation.

Methods: This is a single-center, retrospective, video review-based study conducted between October 2018 and February 2024. It includes video-recorded patients with OHCA aged 18 and older and excludes patients with traumatic arrests and out-of-hospital return of spontaneous circulation (ROSC). Groups were based on EMS versus ED monitors/defibrillators/pads use for initial ED rhythm analysis. The primary and secondary outcomes were time to first ED rhythm analysis and time to first ED defibrillation, respectively. The exploratory outcomes were time of ED bed transfer, rates of ROSC, survival to hospital admission/discharge, and neurologic outcome.

Results: Of 223 OHCA patients included, 75 (33.6%) were grouped into EMS and 148 (66.4%) into ED. Out-of-hospital shockable rhythms were reported in 26.5% of EMS and 10.5% of ED groups. The EMS group had a shorter median time to first ED rhythm analysis (143-second difference, 95% confidence interval [CI] 116 to 169) and first ED defibrillation (131.5-second difference, 95% CI 8 to 272). In exploratory analysis, the EMS group had longer time to ED bed transfer (15.0-second difference, 95% CI 0 to 21) and more frequent defibrillation in the ED (18.0% difference, 95% CI 4.2 to 31.8). Forty-four patients survived to hospital admission and 8 survived to hospital discharge.

Conclusion: Initial ED rhythm analysis using EMS equipment may be associated with shorter time to initial rhythm analysis. [Ann Emerg Med. 2026;■:1-6.]

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Keywords: Cardiac arrest, Defibrillator, Emergency medical services (EMS), Transitions of care, Quality improvement.

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INTRODUCTION

Background

Recent guidelines support early defibrillation to improve survival in cardiac arrest (CA).[1-4] However, there is a scarcity of published work specifying strategies for reducing time to defibrillation. Recommendations include immediate defibrillation of shockable rhythms if the defibrillator is already applied and using ancillary waveform technology to identify underlying rhythm during cardiopulmonary resuscitation.[3,5]

Importance

Despite patients with out-of-hospital cardiac arrest (OHCA) often arriving with emergency medical services (EMS) monitors, defibrillators, and pads ("equipment") already attached, it is not always used for the initial emergency department (ED) rhythm analysis. Replacing EMS equipment with ED equipment may prolong the time to first ED rhythm analysis and ED defibrillation, leading to worse outcomes.

Goals of This Investigation

We sought to determine whether the use of EMS equipment is associated with shorter time to first ED rhythm analysis and ED defibrillation.

METHODS

This was a single-center, retrospective cohort study using our CA video review registry data between October

Editor's Capsule Summary

What is already known on this topic

Time to defibrillation is a predictor of cardiac arrest outcome.

What question this study addressed

Does using EMS equipment after emergency department (ED) arrival change time to key care events for those in cardiac arrest?

What this study adds to our knowledge

These unadjusted results suggest that initial rhythm analysis and defibrillation occur sooner if EMS equipment is used on ED arrival.

How this is relevant to clinical practice

Although performing initial rhythm analysis and defibrillation as needed with EMS equipment can shorten delays, the overall impact is uncertain.

3, 2018 and February 20, 2024 in a large, academic, quaternary care ED. Deidentified CA audio/video recordings of resuscitation rooms were uploaded to a secure server with automatic scheduled deletion. Two emergency medicine and critical care-trained physicians with extensive experience in CA video review (D.J. and D.R.) extracted data using a data collection sheet with standardized responses.[6] Sources of data included verbal EMS handoffs, observed key actions by ED team members, critical events video time stamps, and vitals/cardiac rhythm displayed on the resuscitation room monitor. Demographic variables, EMS documentation of out-of-hospital events, functional neurologic status, and patient survival to hospital admission/discharge were abstracted through medical chart review.

Interrater reliability analysis between the 2 video reviewers showed an intraclass correlation coefficient of 0.94 (95% confidence interval [CI] 0.83 to 0.98) for time to first ED rhythm analysis and 1.00 (95% CI 0.99 to 1.00) for time to first ED defibrillation.

Video-recorded patients with OHCA aged 18 years and older were included, whereas the exclusion criteria were traumatic arrests, arrival to the ED with return of spontaneous circulation (ROSC) (and no rearrest), and missing/incomplete video recordings (Figure 1). Patients were categorized into an "EMS" group, if EMS equipment (monitor/defibrillator/pads) was used for initial ED rhythm analysis. If ED equipment was used for initial rhythm analysis, they were categorized into an "ED" group. The primary outcome was the time to first ED rhythm analysis, defined as time between patient arrival to the resuscitation room on video (t_0) and the first video-recorded ED rhythm analysis. The secondary outcome was time to the first ED defibrillation (t_0 to first video-recorded ED defibrillation) in patients with an initial shockable ED rhythm. The exploratory outcomes were time of ED bed transfer (t_0 to ED bed transfer), ROSC rates, survival to hospital admission/discharge, and neurologic outcome.

No formal sample size calculation was performed, given the exploratory nature of the study. Descriptive statistics for categorical variables (frequency and proportion) and continuous variables (mean, median, standard deviation [SD], interquartile range [IQR], minimum, and maximum) were calculated. Categorical variables were compared between the EMS and ED groups using Chi-square tests. Continuous variables were compared between the 2 groups using Wilcoxon rank-sum tests. All statistical analyses were conducted using SAS software Version 9.4 (Cary, NC). The level of significance was set at 5% unless stated otherwise. Our health system's institutional review board approved this study (#19-0115) with exempt status.

RESULTS

Out of 629 patients with CA, 223 met the eligibility criteria, with 75 (33.6%) classified as the EMS group and 148 (66.4%) classified as the ED group (Figure 1). The median age was 80 years (IQR 66 to 88 years), with 57% men. There were no demographic or comorbidity differences except for coronary artery disease between the 2 groups (17.0% difference, 95% CI 4 to 30) (Table 1).

Initial out-of-hospital and initial ED shockable rhythms were 16.0% (95% CI 4.4 to 27.6) and 11.9% (95% CI 1.3 to 22.7) more prevalent in the EMS group, respectively (Tables 1 and 2). There were no differences in other EMS-reported variables between the groups (Table 1).

Median time to first ED rhythm analysis was shorter in the EMS group than that of the ED group (94.0 seconds IQR [54.0 to 163.0 seconds] versus 251.5 seconds IQR [179.5 to 314.5 seconds], $P < 0.0001$). The Hodges-Lehmann estimate of median difference was 143 seconds (95% CI 116 to 169). Median time to first ED defibrillation was also shorter in the EMS group than that of the ED group (120 seconds [IQR 100 to 174 seconds] versus 255 seconds [IQR 188 to 396 seconds]). The Hodges-Lehmann estimate of median difference was 131.5 seconds (95% CI 8 to 272).

Median time to ED bed transfer was longer among the EMS group than ED group (15.0 second difference, 95% CI 0 to 21).

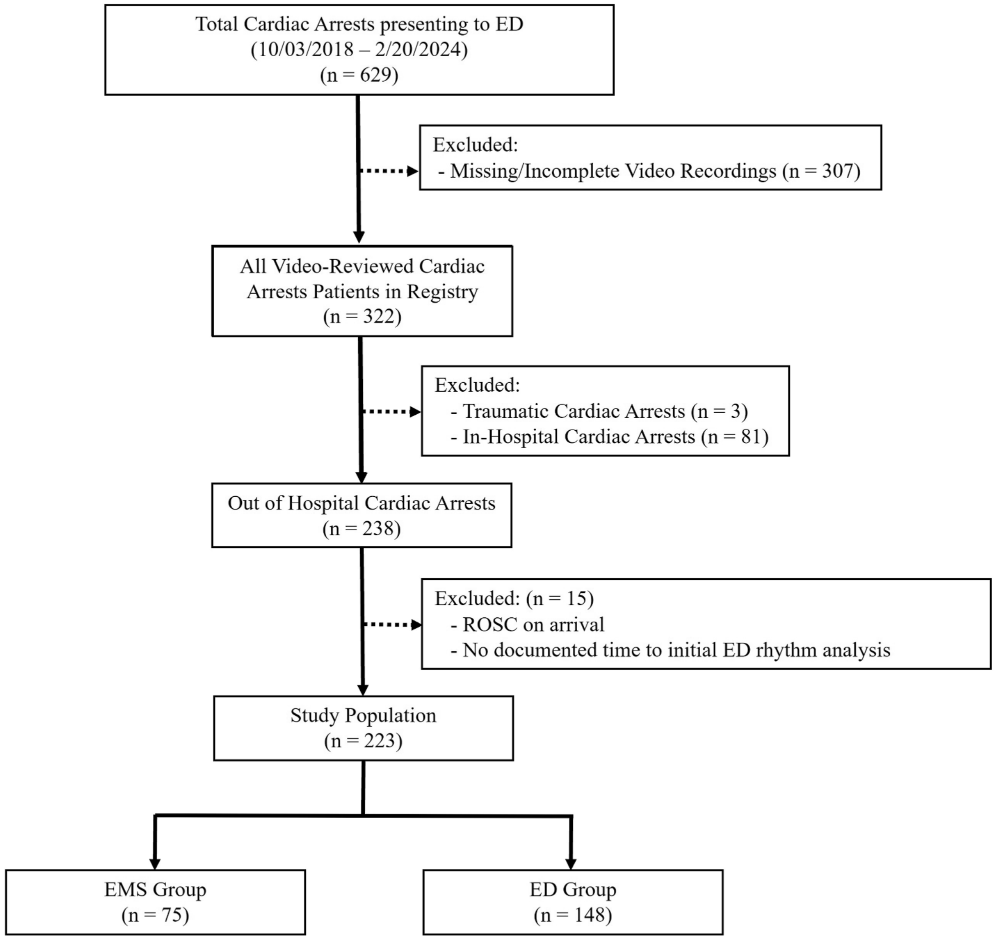

Figure 1. Study flow diagram.

Patients in the EMS group were more frequently defibrillated in the ED than those in the ED group (18.0% difference, 95% CI 4.2 to 31.8). A similar proportion of patients in the EMS and ED groups had ROSC in the ED (10.2% difference, 95% CI –3.4 to 23.8). Forty-four patients survived to hospital admission (20 EMS and 24 ED), and 8 survived to hospital discharge (6 EMS and 2 ED). A higher proportion of patients in the EMS group survived to hospital admission (10.5% difference, 95% CI –1.2 to 25) and hospital discharge (6.7% difference, 95% CI 0.2 to 13.1). The distribution of neurologic outcomes in each group has been provided in Figure 2.

LIMITATIONS

This study has several limitations. First, this is a retrospective, single-center, exploratory study with no sample size calculation, randomization, or power analysis, limiting internal validity and generalizability.

Second, the 2 study groups (“EMS” and “ED”) are significantly confounded by indication. In this study, we have identified 2 potential confounding variables (out-of-hospital rhythm and coronary artery disease history), but the group assignment can be based on provider/team preference, equipment malfunctions/compatibility, patient factors, OHCA circumstances, operational factors, and/or resuscitation dynamics. Therefore, our study cannot prove benefit or causality and can only be hypothesis-generating.

Third, due to the small sample size, any inferential analysis of survival outcomes would be underpowered and infeasible. We have established a multicenter CA video review registry with a standardized data collection to validate our findings.

Fourth, a significant portion of patients with OHCA were excluded, given that the primary outcome was derived from video review. Excluded patients may differ systematically, which could introduce selection bias. However, a comparison of the basic demographics showed no differences. Additionally, exclusion of patients with out-of-hospital ROSC may have introduced collider bias.

Finally, data collection through video review has limitations. Video review cannot account for any significant events that occurred off-video including what

Table 1. Demographics, medical history, and EMS-reported variables of the cohort.

Characteristics and Out-of-Hospital Variables	EMS, n (%)	ED, n (%)
N	75 (33.6)	148 (66.4)
Sex (male)	45 (60.0)	82 (55.4)
Age*	82 (65-87)	80 (66-88)
Race		
Asian	15 (20.0)	13 (8.8)
Black	4 (5.3)	18 (12.2)
Other/Multiracial	8 (10.7)	18 (12.2)
Unknown	7 (9.3)	23 (15.5)
White	41 (54.7)	76 (51.4)
Ethnicity		
Non-Hispanic/Latino	64 (85.3)	119 (80.4)
Hispanic/Latino	3 (4.0)	3 (2.0)
Unknown	8 (10.7)	26 (17.6)
Medical history		
Hypertension	40 (53.3)	82 (55.4)
Diabetes mellitus	27 (36.0)	46 (31.1)
Hyperlipidemia	21 (28.0)	45 (30.4)
Coronary artery disease	30 (40.0)	34 (23.0)
Congestive heart failure	20 (26.7)	26 (17.6)
Renal insufficiency	13 (17.3)	20 (13.5)
Chronic obstructive pulmonary disease	12 (16.0)	22 (14.9)
Active malignancy	2 (2.7)	6 (4.1)
EMS-Reported Variables		
Witnessed arrest (n = 202)	41 (63.1)	78 (56.9)
Estimated downtime* (minutes) (n = 155)	38.8 (25.0-47.0)	39.0 (25.0-51.0)
Bystander CPR (n = 190)	21 (35.0)	35 (26.9)
Intubated prior to ED arrival (n = 218)	62 (84.9)	107 (73.8)
Shockable initial EMS rhythm (n = 211)	18 (26.5)	15 (10.5)
Shocked prior to ED (n = 149)	25 (50)	33 (33.3)

*Median (interquartile range)

happens en-route (ie, ED pads placement, medications administered, or defibrillations). We attempted to mitigate this loss of important information by incorporating EMS and medical chart data into our analysis.

DISCUSSION

While the fundamental differences in the EMS and ED groups make it challenging to interpret our findings, we can offer multiple potential explanations. Switching to ED equipment takes more time and it is likely that ED providers *chose* to use EMS equipment to prioritize faster initial rhythm analysis/defibrillation informed by an out-of-hospital shockable rhythm (16.0% higher prevalence in the EMS group). We previously found that initial out-of-hospital rhythm was communicated in 79% of EMS-ED handoffs and was considered an essential component of OHCA handoffs.[7,8] However, we cannot confirm what factors influenced EMS versus ED group assignments, because we did not collect clinician insights for this study.

Alternatively, although the same caution must be exercised when interpreting our exploratory outcomes, a shorter time to initial ED rhythm analysis can hypothetically explain the higher proportion of shockable initial ED rhythms and defibrillations in the EMS group. Cournoyer et al[9] showed that the probability of observing an initial shockable rhythm in the first few minutes of OHCA resuscitation decreased by 3% to 5% per minute of

Table 2. CA characteristics.

Outcomes	EMS	ED	Differences [95% CI]
Time to first ED rhythm analysis* (n = 223) (s)	94.0 (54.0-163.0)	251.5 (179.5-314.5)	143 [116-169]
Time to first ED defibrillation* (n = 24) (s)	120 (100-174)	255 (188-396)	131.5 [8-272]
Time to ED bed transfer* (n = 210) (s)	71.0 (48.0-93.0)	56.0 (40.5-85.0)	11 [0-21]
Shockable initial ED rhythm (n = 202) (%)	15 (21.1)	12 (9.2)	12 [1.3-22.7]
Defibrillation in ED (n = 204) (%)	32 (45.1)	36 (27.1)	18 [4.2-31.8]
ROSC in ED (n = 223) (%)	34 (45.3)	52 (35.1)	10.2 [-3.4 to 23.8]

"*Differences,*" percent differences for binary variables and Hodges-Lehmann estimates of median differences for continuous variables.
*Median (interquartile range)

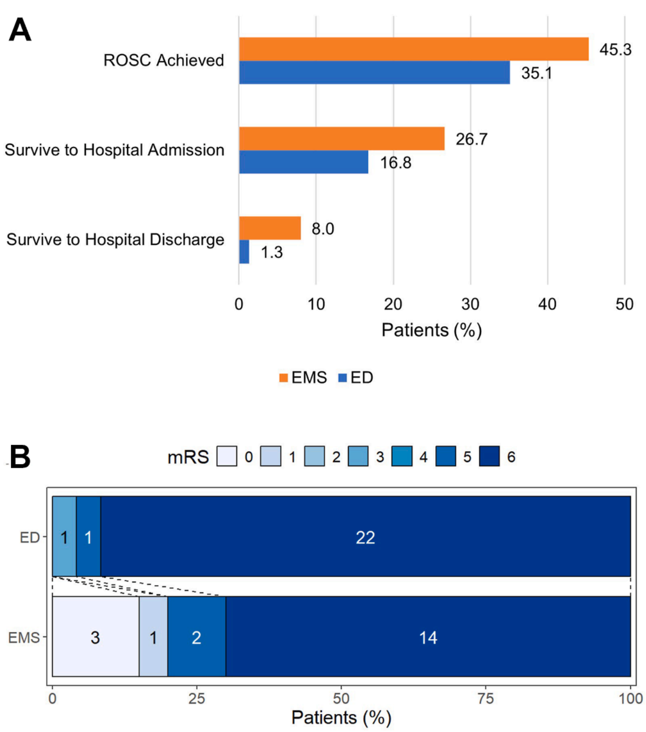

Figure 2. (*A*) Key secondary outcomes demonstrating the trend in improved outcomes with the EMS pads group. (*B*) mRS plot showing the distribution of neurologic outcomes in EMS pads and ED pads patients who survived to hospital admission. Modified Ranking Score (mRS) is a 6-point neurologic disability scale: 0 = no residual symptoms; 1 = no significant disability, able to carry out all preneurologic event activities; 2 = slight disability, unable to carry out all preneurologic event activities but able to look after self without daily help; 3 = moderate disability, requiring some external help but able to walk without the assistance of another individual; 4 = moderately severe disability, unable to walk or attend to bodily functions without assistance of another individual; 5 = severe disability, bedridden, incontinent, requires continuous care; 6 = expired (during the hospital stay or after discharge from the hospital).

delay. However, a more parsimonious explanation is that ED providers *chose* to use EMS equipment because an out-of-hospital shockable rhythm was communicated, meaning the higher shockable rate in the EMS group reflects patient selection rather than faster analysis. Due to the limited sample size, confounding by indication, and selection bias, we are unable to establish the former explanation.

Similarly, there is evidence that a delay in initial rhythm analysis can lead to poorer outcomes. Verkaik et al[10] and Felder et al[11] reported a 7% to 15% decrease in patient survival to hospital discharge with each minute initial defibrillation was delayed. Although our survival/neurologic outcome results (Figure 2) are interesting, it should be emphasized that our results are not proof of such associations, as the baseline differences between groups (ie, higher prevalence of out-of-hospital shockable rhythms in the EMS group) and confounding by indication preclude attributing these outcome differences to equipment choice. It is plausible, but unproven that EMS equipment use may be associated with better outcomes.

Using EMS equipment for initial ED rhythm analysis is simple, applicable to all OHCAs (regardless of patient characteristics and out-of-hospital rhythm/interventions), avoids further chest compressions interruptions, and facilitates dual sequential defibrillation especially in shock-refractory patients with OHCA.[12] Adopting this approach may also improve the quality of EMS-ED handoffs as it prioritizes a brief pause before ED bed transfer for rhythm analysis during which EMS can initiate their handoff. In our ED, we have created a standardized OHCA handoff checklist (including out-of-hospital rhythms) and since 2024 we have transitioned to using EMS equipment for initial ED rhythm analysis for all OHCAs.[6,7]

This study has several strengths. It leveraged the largest, OHCA, video review data registry over 6 years. Video review allowed for high temporal accuracy in recording critical events/interventions with frame-by-frame analysis and a single time-recording device as a reference for all time intervals. It also permitted simultaneous evaluation of multiple performance variables due to audio/video playback features and data collection from multiple proprietary devices (ie, defibrillators and ultrasound machines) that are all visible on video review. The 2 video reviewers also demonstrated strong agreement.

In conclusion, this video review-based exploratory study of patients with OHCA showed that the use of EMS equipment for initial ED rhythm analysis may be associated with decreased time to initial ED rhythm analysis and defibrillation.

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Author contributions: DJ and DR extracted data by reviewing video recordings of out-of-hospital cardiac arrests occurring at Northwell Health. DJ and DR worked with GH, MMP, EY, TL, and LB to extract data from chart reviews and consolidate data into a database for future analysis. DJ conceived this study and worked with RR, EC, and XH to extract data from the database and carry out the investigation. XH and DJ performed the statistical analysis for this study. RR, EC, XH, and DJ worked together to write/edit the manuscript and generate the tables and figures. All authors reviewed and/or edited the manuscript. DJ takes responsibility for the paper as a whole.

Data sharing statement: The entire deidentified data set and analysis for this investigation are available on request from the date of article publication by contacting Daniel Jafari, MD at djafari@northwell.edu.

All authors attest to meeting the four ICMJE.org authorship criteria: (1) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (2) Drafting the work or revising it critically for important intellectual content; AND (3) Final approval of the version to be published; AND (4) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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