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ORIGINAL RESEARCH

Effectiveness of an Online Body Camera System for Medical Oversight in Prehospital Emergency Care: An 11-Year Retrospective Cohort Study

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Abstract: **Introduction:** The online body camera system (OBCS) integrates telemedicine technology with real-time monitoring of on-scene operations, direct online medical direction, and coordinated patient care. This study aimed to evaluate its effectiveness compared with the traditional telephone-based medical oversight system. **Methods:** This retrospective cohort study evaluated the effectiveness of OBCS in prehospital emergency care of Ramathibodi Hospital by comparing outcomes (survival rate, length of stay) between the traditional telephone-based (2014–2021) and the OBCS periods (2022–2024) in emergency medical operation unit. **Results:** This 11-year retrospective cohort study analyzed 5,721 prehospital emergency care cases (3,398 cases managed under the traditional telephone-based system and 2,323 cases managed under the OBCS). The findings indicate that the implementation of the OBCS significantly improved overall survival to emergency department (ED) arrival (adjusted odds ratio (aOR) = 8.32, 95% CI: 1.47–47.14, P = 0.017), particularly among out-of-hospital cardiac arrest (OHCA) patients (aOR = 7.99, 95% CI: 1.28–50.03, P = 0.026). However, the new system did not result in significant improvements in survival to hospital admission or survival to hospital discharge. Furthermore, the length of stay (LOS) in the ED, intensive care unit (ICU), and overall hospital setting remained unchanged. **Conclusion:** The OBCS significantly enhanced survival to ED arrival, particularly among OHCA patients. However, the LOS in the ED, ICU, and overall hospital setting remained unchanged.

Keywords: Emergency Medical Services; Telemedicine; Medical Director; Telecommunications; prehospital emergency care

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1. Introduction

Prehospital care has undergone significant evolution, integrating a wide range of advanced life-saving interventions to enhance emergency medical response and improve patient outcomes (1). These include non-invasive ventilation for patients experiencing severe respiratory distress (2), prehospital intraosseous access for emergency vascular access (3), and mechanical cardiopulmonary resuscitation devices, which replace manual chest compressions (4). Additionally, prehospital thrombolysis has become a valuable intervention in acute stroke management (5, 6), while ultrasound is increasingly utilized for diagnostic purposes in the prehospital setting (7). The use of specialized medications has also advanced. Examples include hydroxocobalamin for cyanide poisoning (8) and tranexamic acid to mitigate bleeding in trauma patients (9, 10). Moreover, complex procedures such as Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) have been adopted to temporarily control hemorrhage and stabilize trauma patients as they are prepared for definitive surgical intervention (11, 12). In select cases, extracorporeal membrane oxygenation (ECMO) has emerged as a life-saving prehospital intervention, providing critical circulatory and respiratory support (13, 14).

Telemedicine in EMS has evolved significantly over the decades, playing a crucial role in prehospital patient monitoring, bridging the gap between prehospital care providers and specialists, assisting medical directors in making informed decisions regarding prehospital care, and helping determine the appropriate hospital for patient transport (15-17). Numerous studies demonstrate the benefits of telemedicine in the management of conditions such as stroke (18), myocardial infarctions, air medical operations (19), and other aspects of prehospital care. These advancements improve patient outcomes by facilitating real-time communication, expert guidance, and timely interventions during the critical prehospital phase (20).

Prehospital emergency care under the Emergency Medical Operation (EMO) Unit of Ramathibodi Hospital was formally established in 2014. To strengthen clinical supervision and

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ensure adherence to medical standards in the field, the unit implemented an online body camera system (OBCS), a wearable device attached to paramedics that enables real-time audiovisual communication with the on-duty medical director. Through this system, the medical director could provide immediate oversight, clinical guidance, and decision support during on-scene patient management.

Prior to the implementation of the OBCS (2014–2021), prehospital medical direction at Ramathibodi Hospital was conducted via telephone communication, which lacked real-time visual capabilities. In 2022, the OBCS was introduced to enable real-time audiovisual communication between paramedics and the on-duty medical director. This advancement allowed the medical director to provide immediate oversight, clinical consultation, and procedural guidance during on-scene patient management.

This study aimed to evaluate the effectiveness of OBCS in prehospital emergency care outcomes compared to traditional online medical oversight.

2. Methods

2.1. Study design and setting

This retrospective cohort study was conducted to assess the effectiveness of the OBCS in prehospital emergency care outcomes (survival and length of stay (LOS) in the emergency department (ED), hospital, and intensive care unit (ICU)) compared to traditional online medical oversight.

The study was approved by The Committee on Human Rights Related to Research, Faculty of Medicine, Ramathibodi Hospital, Mahidol University (IRB COA. MURA2024/343; May 16, 2024). Written informed consent was obtained from each participant, in line with the human rights related to research involving human subjects, as described in the Declaration of Helsinki.

2.2. Participants

The data were collected from the Emergency Medical Record (EMR) system of Ramathibodi Hospital, spanning 11 years from January 1, 2014, to November 20, 2024, across telephone medical direction (2014–2021) and OBCS (2022–2024) periods (Supplement 1). The study included all prehospital patients managed by the EMS of Ramathibodi Hospital. Eligibility criteria were patients aged 18 years and older who exhibited no obvious signs of death at the initial contact with the EMS team.

2.3. Data gathering and outcome measures

Three trained research assistants independently extracted and verified data accuracy. Complete case analysis was applied, and no data imputation was performed.

The primary outcome variables included survival to the emergency department (ED), survival to hospital admission, survival to hospital discharge, and length of stay (LOS) in the ED, intensive care unit (ICU), and hospital. All outcome data were retrospectively reviewed from the EMR by the three research assistants.

Study participants were divided into two groups based on the operational period of EMS medical direction: the telephone-based medical direction period (2014–2021) and the OBCS period (2022–2024).

Exposures, predictors, and potential confounding factors included patient demographics (gender and age), prehospital operation times (activation time, response time, scene time, transport time, and total prehospital time), major disease categories (cardiac arrest, stroke, and trauma), initial on-scene vital signs (blood pressure, heart rate, respiratory rate, and Glasgow Coma Scale [GCS]), and EMS disposition. Subgroup analyses were performed according to major disease categories, out-of-hospital cardiac arrest (OHCA), stroke, and trauma, to determine the differential effects of the OBCS across specific clinical conditions.

2.4. Definitions

Activation Time: The total time elapsed from when the emergency operations center (EOC) at Ramathibodi Hospital receives a dispatch notification from the Erawan Dispatch Center to the moment the notification is relayed to the EMS team provider.

Response Time: The total time elapsed from when the EMS team provider receives the dispatch notification to the arrival of the ambulance at the incident scene (21).

Scene time: The total time elapsed from the ambulance's arrival at the incident scene to its departure from the scene for transport to the appropriate hospital (22).

Prehospital total time: The total time duration from when the EOC at Ramathibodi Hospital receives a dispatch notification from the Erawan Dispatch Center until the patient is transported and arrives at the appropriate hospital (23).

Survival to Emergency Department: Prehospital patients who received on-scene care by the EMS team and remained alive until they were transported to the ED.

Survival to Hospital Admission: Patients who were transported by EMS to the ED, received treatment in the ED during the study period, and subsequently survived to be admitted to the hospital.

Survival to Hospital Discharge: Patients who were transported by EMS, admitted as inpatients during the study period, and survived until hospital discharge.

2.5. Statistical analysis

The sample size estimation was based on the comparison of survival to the ED. With the assumption of a significance level (α) of 0.05 (two-sided) and a power of 0.8, the sample size required to detect a significant difference between the two proportions (92.1% for telephone assist and 89.7% for OBCS) was approximately 2,248 participants per group. To account for 10% expected missing data, the final required sample size was adjusted to approximately 2,498 participants per group.

Data analysis was performed using Stata version 16 (Stata-

Corp LLC, College Station, TX, USA). All study variables and outcomes of interest including: survival to the ED, survival to hospital admission, survival to hospital discharge, ED LOS, ICU LOS, and overall hospital LOS, were compared between telephone-based and OBCS. Categorical variables were analyzed using exact probability tests and reported as frequencies and percentages. Continuous variables were evaluated using Student's t-test for normally distributed data, presented as means with standard deviations (SD). Non-normally distributed variables were reported as medians with interquartile ranges (IQR).

Results were presented as mean differences with 95% CIs and P-values, with statistical significance set at $P < 0.05$. Given the retrospective nature of data collection, complete case analysis was applied to address missing data without implementing imputation methods.

3. Results

A retrospective analysis was conducted over 11 years, from January 1, 2014, to November 20, 2024. During this period, the prehospital emergency team at Ramathibodi Hospital managed 5,721 cases. In the telephone assist, spanning 8 years (2014–2021), 3,398 cases were handled. In contrast, during the OBCS (2022–2024), covering 3 years, 2,323 cases were managed by the prehospital team.

3.1. Patient characteristic

The comparison of patients' characteristics between telephone-based and OBCS medical oversight periods is presented in table 1. There was no significant difference in gender distribution between the two groups. However, the average patient age was significantly higher during the OBCS (56.03±22.54 vs. 59.78±21.53 years; $p < 0.001$). The total number of prehospital cases managed each year showed a significant upward trend, particularly after the implementation of the OBCS. Major disease categories, including OHCA, stroke and trauma, also demonstrated significant yearly increases.

Regarding prehospital operation times across the 11-year span, the OBCS was associated with notable increases in several key time intervals (Figure 1). The median activation time increased significantly from 2 to 5 minutes ($P < 0.001$), the median response time rose from 11 to 16 minutes ($P < 0.001$), the median scene time extended from 14 to 27 minutes ($P < 0.001$), and the median total prehospital time escalated from 28 to 51 minutes ($P < 0.001$).

Most prehospital patients were transported to other hospitals (59.86% vs. 59.10%), while transfers to Ramathibodi Hospital increased from 20.39% to 30.39%. The proportion of patients who died at the scene showed a slight increase (7.06% vs. 7.83%), and the percentage of patients discharged at the scene remained relatively stable (1.29% vs. 1.21%). Finally, the overall survival to ED between 2 periods was not different (92.89% VS 92.17%, p=0.304).

3.2. Subgroup analysis

The average prehospital time for OHCA, stroke, and major trauma patients was significantly longer during the OBCS period compared with the telephone-based oversight period (table 2; $P < 0.001$).

3.2.1 OHCA

A significant improvement in survival to ED arrival was observed during the OBCS period compared with the telephone-based using group (372 (73.96%) patients, vs. 227 (56.07%) patients; $p < 0.001$). However, in the subgroup analysis of OHCA patients transported specifically to Ramathibodi Hospital (103 patients, 20.48%), no significant difference was found in survival to hospital admission or survival to hospital discharge between the two groups. The average ED LOS remained consistent at approximately 3 hours across both groups. Notably, the ICU length of stay decreased from 11 to 9 days in the OBCS group. Although this reduction did not reach statistical significance, it may hold clinical relevance in terms of ICU bed utilization, potentially improving resource allocation and patient flow within the hospital.

3.2.2 Prehospital stroke

In a subgroup analysis of stroke patients transported to Ramathibodi Hospital, approximately 30% of cases were consistent across both study periods. Notably, stroke management efficiency improved during the OBCS period. The door-to-computed tomography (CT) scan time significantly decreased from 30 minutes to 5 minutes ($P < 0.001$), and the door-to- Recombinant Tissue Plasminogen Activator (rTPA) administration time also significantly decreased from 29 minutes to 11.5 minutes ($P < 0.001$). However, the ED LOS remained approximately 3 hours, showing no significant difference between the two groups. Additionally, survival to hospital discharge exceeded 95% in both periods, with no statistically significant difference observed.

3.2.3 Prehospital major trauma

During the period when the OBCS was implemented, the median ICU LOS was notably longer compared with the telephone-based oversight group (6 days vs. 3 days). However, both survival to hospital admission and survival to hospital discharge were significantly higher in the telephone-based group (98.00% vs. 82.18%, $P < 0.001$, and 95.99% vs. 77.23%, $P < 0.001$, respectively). Meanwhile, the ED LOS remained similar between the two groups, at approximately 4 hours, with no statistically significant difference.

4. Discussion

This retrospective 11-year study, conducted at Ramathibodi Hospital, evaluated the impact of an OBCS on key performance indicators within prehospital emergency care. Among OHCA patients, survival to ED arrival was also significantly higher during this period. In stroke management, notable advancements were observed, with the door-to-CT time reduced from 30 to 5 minutes and a faster door-to–rTPA administration time. Although the OBCS improved survival to

ED and OHCA survival to ED arrival, it did not lead to significant improvements in survival to hospital admission or survival to hospital discharge. Furthermore, the LOS in the ED, ICU, and overall hospital settings remained unchanged.

Our study demonstrates a significant increase in prehospital operations during the OBCS, which can be attributed to the implementation of advanced telemedicine technologies, enhanced on-scene procedures, and standardized protocols. These findings align with previous studies that have reported telemedicine's role in increasing both the volume and safety of prehospital cases (25, 26).

Our findings regarding OHCA patients align with previous studies, demonstrating that the implementation of the OBCS, which incorporates telecommunicators providing prearrival instructions for chest compressions and automated external defibrillator (AED) use, significantly improves survival outcomes (27, 28). Additionally, the OBCS has been shown to reduce hand-off time (the duration without chest compressions)(29) and enhance the quality of chest compressions through real-time monitoring (30). The TREAT study, which investigated real-time provider-to-provider telemedical interventions, reported that 84.6% of OHCA cases successfully achieved telemedical consultation (31), a rate comparable to our study, which observed a return of spontaneous circulation in 73.96% of OHCA cases.

The outcomes of prehospital stroke care observed in this study are consistent with previous reports, which have demonstrated that the implementation of an OBCS in conjunction with a dedicated prehospital stroke protocol significantly reduces door-to–CT and door-to–rTPA times (32, 33). However, despite these improvements in prehospital and early in-hospital stroke management, our study lacked sufficient data to determine the effectiveness of the OBCS in improving neurological outcomes at hospital discharge or in reducing hospital LOS. Further research is warranted to evaluate the long-term impact of the OBCS on stroke patient outcomes, including functional recovery and hospital resource utilization.

In summary, the development and implementation of the OBCS in this study demonstrated multiple benefits for patient care. The OBCS has been shown to enhance prehospital patient safety (36) and improve survival rates in critical conditions such as trauma (38) and other life-threatening emergencies (39). In addition, the system enables ambulance teams to bypass the emergency department (ED) and directly transport patients to definitive care facilities when appropriate, thereby reducing treatment delays and optimizing healthcare resource utilization (35, 40, 41).

However, despite these advantages, the OBCS also presents several challenges in prehospital care. One notable concern is the prolonged on-scene time associated with advanced prehospital interventions and real-time communication processes (42). Communication barriers, including environmental noise and unstable connectivity in prehospital settings, may further hinder the effective transmission of critical information (19). Moreover, the cost-effectiveness of the OBCS remains a subject of debate. While some studies have reported inconclusive evidence regarding its economic feasibility (43), others suggest that implementing an OBCS may be more cost-effective than traditional prehospital care models (44). Future research should aim to optimize the balance between the benefits and challenges of the OBCS to ensure efficient implementation while maintaining high standards of patient care and resource utilization.

In the analysis of major trauma patients during the traditional telephone-based period, several key prognostic variables were unavailable. Specifically, data on the prehospital Injury Severity Score (ISS), which reflects trauma severity, as well as information regarding the volume of blood transfusions administered in the ED and hospital, the types of surgical interventions performed, and other critical indicators of injury severity, were missing.

5. Limitations

This study has several limitations that should be considered when interpreting the findings. First, the retrospective design may have introduced biases related to missing or incomplete data, which could affect the accuracy and reliability of the results. Limitations inherent to retrospective data collection may have impacted the completeness of key variables, particularly during the traditional telephone-based period, thereby restricting the ability to perform comprehensive multivariable analyses. Second, as this study was conducted within a single healthcare institution—Ramathibodi Hospital—the findings may not be generalizable to other EMS systems with different operational protocols, resources, or patient populations. Variations in EMS infrastructure, response strategies, and regional healthcare policies may influence the applicability of these results to broader settings.

In addition, the absence of several key variables from the traditional telephone-based period poses challenges for direct comparison and limits the capacity to fully assess the impact of the OBCS. The inability to adjust for certain confounding factors, such as differences in prehospital team experience, resource availability, and variations in clinical management, further constrains the interpretation of the outcomes. As this study was designed to collect data during the period following the implementation of the OBCS (from 2022 to 2024), a total of 2,323 eligible cases were included. Lastly, unmeasured confounders, including patient comorbidities, hospital capacity fluctuations, and differences in patient pathways across study periods—may also have influenced the findings. Future prospective studies with robust data collection frameworks, multicenter participation, and standardized clinical and operational protocols are warranted to validate these results and to evaluate the long-term impact and cost-effectiveness of the OBCS across diverse EMS settings.

6. Conclusions

The implementation of the OBCS enhanced survival to ED arrival, particularly among OHCA patients. However, despite these improvements, the LOS in the ED, ICU, and overall hospital setting remained unchanged. Further research is warranted to evaluate the long-term impact of the OBCS on patient outcomes, healthcare efficiency, and resource utilization.

7. Declarations

7.1. Acknowledgments

None.

7.2. Authors' contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

7.3. Ethical considerations

This study was approved by The Committee on Human Rights Related to Research, Faculty of Medicine, Ramathibodi Hospital, Mahidol University (IRB COA. MURA2024/343; May 16, 2024).

7.4. Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

7.5. Funding Source

No funding was obtained for this study.

7.6. Competing interests

The authors declare that they have no competing interests.

7.7. Using artificial intelligence chatbots

During the preparation of this work the author(s) used ChatGPT4.0 and Grammarly's AI in order to check and correct grammatical errors during the manuscript writing process. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

7.8. Consent to Participate in declaration

Written informed consent was obtained from each participant, in line with the human rights related to research involving human subjects, as described in the Declaration of Helsinki.

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Table 1: Comparison of patient characteristics between telephone-based system (TBS) and online body camera system (OBCS) medical oversight periods

Characteristics	TBS (n = 3,398)	OBCS (n = 2,323)	P-value
Gender			
Male	1,876 (56.39)	1,317 (56.89)	0.723
Age (years)			
Mean ± SD	56.03 ± 22.54	59.78 ± 21.53	< 0.001
Major disease groups			
Cardiac arrest	447 (13.15)	504 (21.70)	< 0.001
Trauma	305 (8.98)	330 (14.21)	< 0.001
Stroke	97 (2.85)	156 (6.72)	< 0.001
Operation Times (minute)			
Activate time	2 (1–3)	5 (3–7)	< 0.001
Response time	11 (7–15)	16 (12–22)	< 0.001
Scene time	14 (9–21)	27 (20–40)	< 0.001
Prehospital total time	28 (20–40)	51 (40–65)	< 0.001
Vital signs (on scene)			
Systolic blood pressure (mmHg)	134.02 ± 32.82	130.87 ± 34.00	0.004
Heart rate (per minute)	96.03 ± 23.37	97.80 ± 24.56	0.023
Respiratory rate (per minute)	22.21 ± 5.40	21.96 ± 5.13	0.155
Glasgow Coma Scale	14 (7–15)	14 (7–15)	0.680
Prehospital disposition			
Missing data	21 (0.62)	1 (0.04)	
Transport to Ramathibodi hospital	693 (20.39)	706 (30.39)	< 0.001
Transport to other hospital	2,034 (59.86)	1,373 (59.10)	
Death at scene	240 (7.06)	182 (7.83)	
Discharge at scene	44 (1.29)	28 (1.21)	
Refusing treatment	366 (10.77)	33 (1.42)	
Overall survival to ED			
Rate (%)	3,135/3,375 (92.89)	2,141 (92.17)	0.304

Data are presented as mean ± standard deviation (SD), frequency (%), or median (interquartile range). ED: emergency department.

Supplement 1: A body camera, enabling real-time visual and audio communication with the on-duty medical director.

Table 2: Subgroup analysis of major diseases between telephone-based system (TBS) and online body camera system (OBCS) medical oversight periods

Subgroup	TBS (N=499)	OBCS (N=503)	P-value
Out-of-hospital cardiac arrest			
Activate time (minute)	2 (1–4)	5 (3–7)	< 0.001
Response time (minute)	11 (8–16)	17 (13–22)	< 0.001
Scene time (minute)	20 (10–36)	33 (23–49)	< 0.001
Prehospital total time (minute)	38 (25–52)	58 (45–72)	< 0.001
Survival to ED	227/405 (56.07)	372 (73.96)	< 0.001
Transport to Ramathibodi hospital	84/494 (17.00)	103/503 (20.48)	< 0.001
Survival to admission	31/84 (36.90)	51/103 (49.5)	0.624
ED LOS (hours)	3 (1–9)	3 (2–11)	0.971
Survival to hospital discharge	16 (19.05)	18 (17.48)	0.850
ICU LOS (day)	11 (9–12)	9 (2–15)	0.884
Stroke			
Activate time (minute)	2 (1–3)	5 (4–7)	< 0.001
Response time (minute)	11 (7–15)	16 (12–21)	< 0.001
Scene time (minute)	14 (10–22)	25 (20–37)	< 0.001
Prehospital total time (minute)	28 (22–38)	48 (40–64)	< 0.001
Transport to Rama	41 (32.54)	46 (29.87)	0.409
Door to CT (minute)	30 (22–39)	5 (4–6)	< 0.001
Door to rTPA (minute)	29 (18–40)	11.5 (10–14)	< 0.001
ED LOS (hours)	3 (2–6)	3 (2–14)	0.191
Survival to hospital discharge	33 (94.29)	42 (95.45)	0.989
Major trauma			
Activate time (minute)	2 (1–2)	4 (3–7)	< 0.001
Response time (minute)	7 (4–9)	12 (8–17)	< 0.001
Scene time (minute)	10 (6–15)	22 (16–29)	< 0.001
Prehospital total time (minute)	18 (12–27)	39 (29–53)	< 0.001
ED LOS (hours)	3.5 (2–7)	4 (2–7)	0.521
Survival to admission	98/100 (98.00)	83/101 (82.18)	< 0.001
Survival to hospital discharge	95/100 (95.00)	78/101 (77.18)	< 0.001
ICU LOS (days)	3 (0–11)	6 (3–11)	0.180

Data are presented as mean ± standard deviation (SD), frequency (%), or median (interquartile range). ED: Emergency Department; CT: Computed Tomography; rTPA: Recombinant Tissue Plasminogen Activator; LOS: Length of Stay; ICU: Intensive Care Unit.

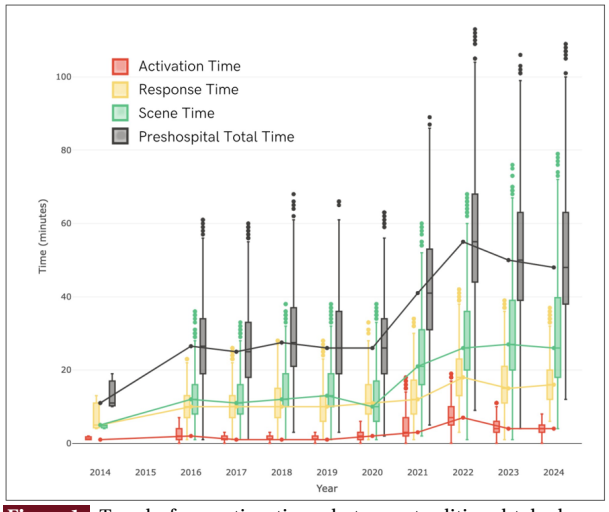

Figure 1: Trend of operation times between traditional telephone (2014–2021) and online body camera system periods (2022–2024).