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Original Research

Reducing Door-to-Balloon Time Using EMS-Initiated App-Based Communication

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ABSTRACT

Background: Reducing door-to-balloon (D2B) time for ST-segment elevation myocardial infarction (STEMI) has been shown to improve outcomes. Delays still occur due to various factors such as time to laboratory activation and diagnostic clarification in equivocal cases. We propose that early communication through a mobile application (app) between emergency medical services (EMS) and in-hospital providers can reduce EMS-to-balloon time and provide coordinated care to impact D2B time.

Methods: The General Devices e-Bridge mobile app, which allows real-time communication and data transmission between EMS providers and the cardiac catheterization laboratory and emergency department staff, was implemented on May 14, 2019. A single-center, retrospective observational study was conducted on 795 STEMI activations undergoing emergent coronary angiography between January 2017 and July 2020. After exclusions, EMS transmissions of 428 cases were analyzed, of which 132 used the app.

Results: Implementation of e-Bridge significantly reduced D2B time by 7.2 minutes ($P = .005$) and emergency department board time by 4.41 minutes ($P = .01$). First medical contact to balloon (FMC2B) time trended toward reduction but was not statistically significant. The app did not significantly reduce D2B or FMC2B time during the day shift but significantly improved these metrics during the night shift.

Conclusions: Implementation of app-based communication between EMS and in-hospital providers resulted in statistically significant reductions in D2B time at our institution. This approach holds promise in improving the timely management of STEMI patients, particularly during the night shift.

The door-to-balloon (D2B) time is a well-established benchmark for measuring the quality of primary percutaneous coronary intervention (PCI) in patients with ST-elevation myocardial infarction (STEMI).[1] An incremental delay in D2B time is associated with an increased relative risk of in-hospital mortality and worse patient outcomes.[2] Early activation of the cardiac catheterization laboratory (CCL) by emergency medical services (EMS) has been shown to be an effective strategy in reducing D2B time.[3–5] Communication between EMS and in-hospital providers plays a crucial role in facilitating appropriate triage, diagnosis, and initial management.

New communication technologies, such as real-time wireless transmission of data from the field to receiving hospitals, aim to minimize delays in diagnosis and triage before patients arrive at the hospital. While studies have shown the benefits of application (app)-based communication for stroke patients, the impact on D2B times for STEMI patients has been inconclusive.[6] However, a single-center study in Beijing demonstrated that a telemedicine app called the Tiantanzhixin app improved D2B times both before and after the COVID-19 pandemic.[7] This app facilitated real-time communication and online consultation between patients and the hospital. Lastly, a Prospective QI project, the WhatsApp-STEMI Trial, used a commonly used text-based app to facilitate real-time communication with emergency department (ED) staff and cardiologists with clinical decision pathways to improve key performance indicators including door-to-ECG, DTB times, and false catheterization lab activations.[8]

In an effort to enhance prehospital communication and transmit electrocardiograms (ECGs) between EMS, the ED, and the STEMI team, we acquired the e-Bridge mobile telemedicine app (General Devices Company, Inc). We provided training to all EMS agencies free of cost with the primary objective of improving the time from first medical contact to balloon time (FMC2B) and D2B. As of now,

Abbreviations: CCL, cardiac catheterization laboratory; D2B, door-to-balloon time; EMS, emergency medical services; FMC2B, first medical contact to balloon time; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction.

Keywords: app; door-to-balloon time; first medical contact to balloon time; ST-segment elevation myocardial infarction.

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Table 1. Effect of mobile application.

	Time with use of app, min	Time without use of app, min	Mean difference in times, min	*P*	95% CI of the difference
D2B	61.2 ± 24.3	68.36 ± 24.61	−7.17	.005	−12.2 to −2.14
FMC2B	94.87 ± 26.52	100.24 ± 28.03	−5.37	.071	−11.21 to 0.46
Time in the ED	24.98 ± 15.45	29.38 ± 17.18	−4.41	.011	−7.81 to −1.00
Travel time	17.82 ± 8.94	19.66 ± 10.61	−1.83	.82	−3.9 to 0.23

Values are mean ± SD unless otherwise noted.
D2B, door-to-balloon time; ED, emergency department; FMC2B, first medical contact to balloon time.

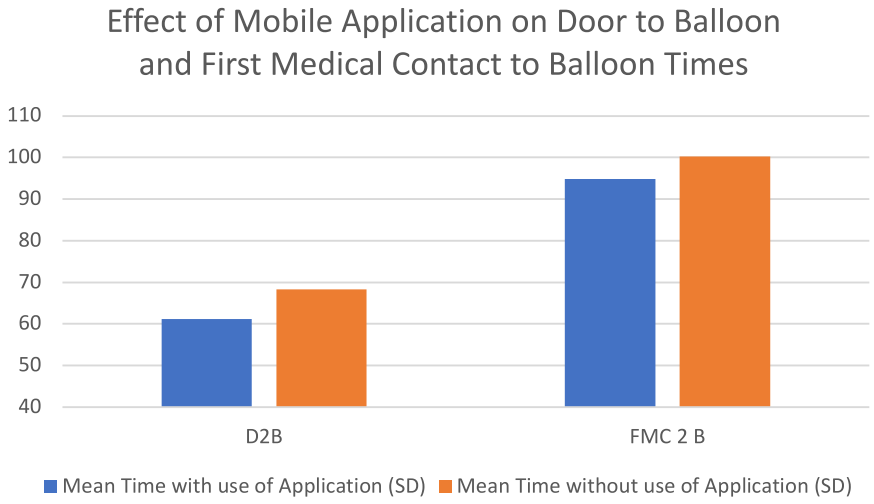

Figure 1.
Effect of mobile application on door-to-balloon and first medical contact to balloon times (in minutes). D2B, door-to-balloon time; FMC2B, first medical contact to balloon time.

no similar studies have been published, making this endeavor an innovative approach to improving STEMI patient care.

Methods

The project was implemented following comprehensive training provided to participating EMS agencies, ED staff, CCL staff, and physicians. User accounts were granted to private EMS agencies and hospital personnel at no cost. These accounts are password protected and adhere to Health Insurance Portability and Accountability Act security standards, allowing for secure usage on any smart device. In addition, smart tablets were strategically installed throughout the ED and CCL areas.

We performed a retrospective observational cohort study, which received review and approval for waiver from the Baystate Medical Center Institutional Review Board. The study population comprised individuals aged ≥18 years with ST-segment elevation >1 mm in 2 contiguous ECG leads lasting >30 minutes or those with a new left bundle branch block or clinical syndrome indicative of acute evolving transmural myocardial infarction necessitating immediate interventional reperfusion therapy. We excluded cases involving interfacility transfers, STEMI diagnoses based on subsequent ECGs, late presentation of STEMI, known bleeding disorders, cases where no PCI procedure was performed, and instances where thrombolytics were administered. Cases with delays in PCI due to nonsystemic factors were not excluded in either group. The primary endpoints assessed in this study included FMC2B, D2B, door to leave ED time, and EMS travel time in minutes. Additionally, we collected data on the rate of false STEMI activations.

To protect patient confidentiality, all data were deidentified and stored on a password-protected computer system. Patient anonymity was ensured by coding all collected data. Importantly, none of the investigators involved in this study had any personal or financial interests that could potentially influence their objectivity in data gathering, analysis, or the recommendations they made based on the study results.

For the statistical analysis of the collected data, we utilized SPSS version 29 (IBM Corp).

Results

We identified a total of 795 STEMI cases that underwent emergent coronary angiography at our institution between January 2017 and July 2020. After excluding interfacility transfers, cases without indication for or contraindications to PCI, and those who received thrombolytics, our final sample size was 428. Out of these, EMS transmissions using the mobile app were used in 132 patient cases since its implementation on May 14, 2019.

Table 2. Effect of day shift and night shift on door-to-balloon time, first medical contact to balloon time, ED leave time, and travel time.

	Day shift, min	Night shift, min	Mean difference, min	*P*	95% CI of the difference
D2B	63.02 ± 24.04	71.67 ± 25	−8.65	.001	−13.5 to −3.77
FMC2B	94.47 ± 26.51	104.98 ± 28.23	−10.51	.001	−16.44 to −4.59
Time in the ED	24.42 ± 14.55	33.95 ± 18.47	−9.53	.000	−13.03 to −6.03
Travel time	18.94 ± 10.3	19.09 ± 9.7	−0.147	.892	−2.27 to 1.98

Values are mean ± SD unless otherwise noted.
D2B, door-to-balloon time; ED, emergency department; FMC2B, first medical contact to balloon time.

Table 3. Effect of e-Bridge during day shift (n = 273).

	With e-Bridge, min	Without e-Bridge, min	Mean difference, min	*P*	95% CI of the difference
D2B	59.78 ± 22.13	64.56 ± 24.80	−4.78	.111	−10.66 to 1.10
FMC2B	92.94 ± 24.07	95.38 ± 27.90	−2.43	.486	−9.30 to 4.44
Time in the ED	23.67 ± 14.196	24.80 ± 14.76	−1.14	.556	−4.95 to 2.67
Travel time	17.36 ± 9.32	19.90 ± 10.77	−2.54	.062	−5.21 to 0.13

Values are mean ± SD unless otherwise noted.
D2B, door-to-balloon time; ED, emergency department; FMC2B, first medical contact to balloon time.

Table 4. Effect of e-Bridge during night shift (n = 155).

	With e-Bridge, min	Without e-Bridge, min	Mean difference, min	*P*	95% CI of the difference
D2B	64.02 ± 28.22	74.70 ± 23.04	−10.68	.029	−19.23 to −2.019
FMC2B	98.63 ± 30.73	108.11 ± 26.54	−9.48	.084	−20.27 to 1.32
Time in the ED	27.6 ± 17.58	36.46 ± 18.29	−8.87	.008	−15.32 to − 2.41
Travel time	18.73 ± 8.15	19.27 ± 10.41	−0.54	.744	−3.81 to 2.73

Values are mean ± SD unless otherwise noted.
D2B, door-to-balloon time; ED, emergency department; FMC2B, first medical contact to balloon time.

Patients for which the app was utilized had an average D2B time of 61.2 minutes, compared with those in which it was not (68.4 minutes). This resulted in a mean difference of 7.2 minutes (95% CI, −12.2 to 2.14) (Table 1, Figure 1). Additionally, the utilization of the app led to a statistically significant reduction in ED leave time by 4.4 minutes. There was also a trend toward improvement in the FMC2B time, but it was not statistically significant. However, there was no significant difference in travel time between the 2 groups (Figure 1).

During the day shift, there were a total of 273 CCL activations, whereas during the night shift, there were 155. Comparing the day and night shifts, the mean D2B, FMC2B, and ED board times were all significantly lower during the day shift (Table 2). However, when looking specifically at the utilization of the mobile app, there was no statistically significant reduction in these metrics during the day shift (Table 3). On the other hand, during the night shift, use of the app resulted in improvements of 10.7 minutes in D2B time and 8.9 minutes in ED leave time (Table 4, Figure 2). The mean difference in FMC2B time was 9.5 minutes, but this difference was not statistically significant. Furthermore, there was no statistically significant difference in travel time in cases for which the app was utilized.

Discussion

This study aimed to evaluate the impact of an app-based communication system on reducing D2B and FMC2B times in patients with STEMI. The results showed a statistically significant reduction in D2B time by 7.2 minutes ($P = .005$) and in ED board time by 4.41 minutes ($P = .01$) when the app was utilized (Central Illustration).

These findings are consistent with the hypothesis that early communication between EMS providers in the field and in-hospital providers can lead to integrated STEMI care with the goal of improved outcomes. Through a unified communication system that allows transmission of prehospital history, vitals, ECGs, and change in clinical status, the app facilitates more efficient triage, accurate diagnosis, and initial management of STEMI patients, resulting in reduced

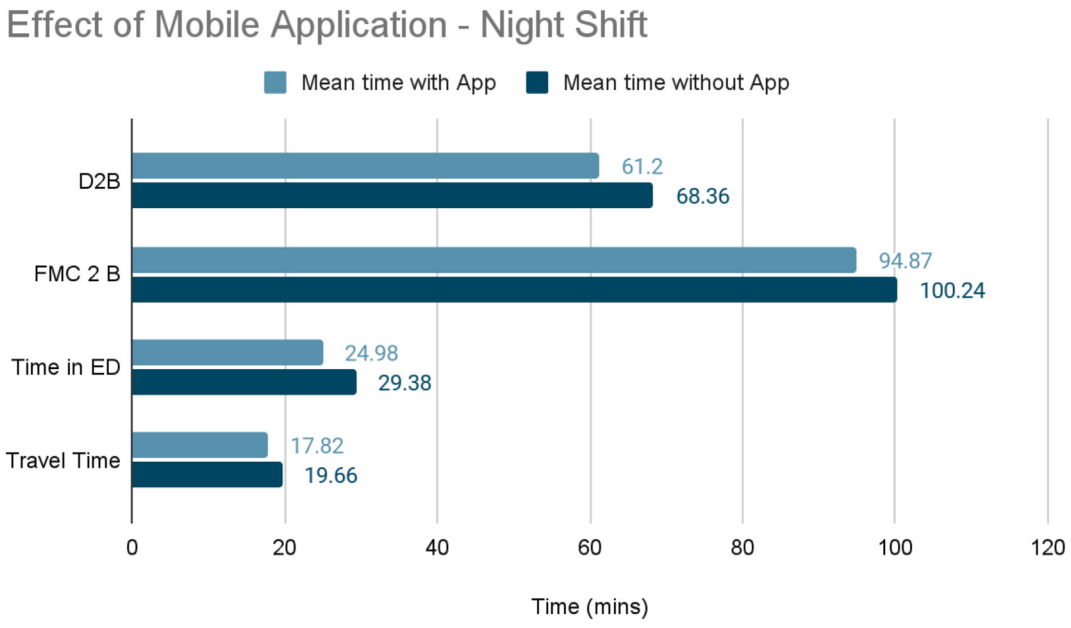

Figure 2.
Effect of mobile application after hours. D2B, door-to-balloon time; ED, emergency department; FMC2B, first medical contact to balloon time.

CENTRAL ILLUSTRATION: EMS Initiated App Based Communication Reduces Door To Balloon Time.

	Mean Time with App	Mean Difference	p-value	Mean Time without App
Door To Balloon (mins)	61.2	-7.17	0.005	68.36
First Med Contact to Balloon (mins)	94.87	-5.37	0.071	100.24
Door To Balloon After hours (mins)	64.02	-10.68	0.029	74.70
First Medical Contact to Balloon After hours (mins)	98.63	-9.48	0.084	108.11

Central Illustration.

EMS-initiated app-based communication reduces door-to-balloon time.

The impact of an EMS-initiated app-based communication system on door-to-balloon (D2B) time in acute myocardial infarction (AMI) patients. The data compares D2B times before and after the implementation of the app. The app facilitates real-time communication between EMS and hospital cardiology teams, leading to improved coordination and faster treatment D2B times. ED, emergency department; ECG, electrocardiogram; EMS, emergency medical services.

D2B and ED board times. In addition, the cardiac critical care unit is part of the notification process, which allows for preparation for the patients, especially if the patient is in critical condition.

It is worth noting that while there was a trend toward improvement in FMC2B time by 5.37 minutes, this did not reach statistical significance. Nonetheless, the results are consistent with the overall findings. Further research may be needed to explore strategies specifically targeting FMC2B time reduction.

Additionally, the study analyzed the impact of the app during different shifts and found that the improvements in D2B time and ED leave time were significant during the night shift but not during the day shift. Hospitals are operational 24 hours a day, 7 days a week; however, staffing, patient volume, and resources vary during off hours, which includes nights, holidays, and weekends. The benefit of the app allowed for an integrated approach to time-sensitive management of patients with STEMI and reduced the variability that is present between on- and off-hours care. By providing more comprehensive information to the ED and interventional team, it allowed for early mobilization and preparation for the patient to arrive to the CCL, which resulted in reduced ED board times during the night shift (8.87 minute improvement in off-hours shift ED board time; $P = .008$).

The study has several strengths, including a relatively large sample size and a rigorous statistical analysis. However, there are limitations to consider. The study design was retrospective and observational, which may introduce biases and confounding factors. The generalizability of the findings may also be limited to the specific institution and context in which the study was conducted. We were not able to assess the benefit of app utilization in detecting false negative STEMI rates based on the nature of data collection at the time, which should be further studied. Despite current advances, the prevalence of false activations remain high, are due to multiple patient and non-patient factors, and are of significant financial burden.[9–10] Finally, the net clinical benefit of utilizing this app was not assessed in this study. We believe this workflow will be most beneficial during the off hours including nights, weekends, and holidays, particularly in programs with borderline D2B times.

In conclusion, the implementation of an app-based communication system between EMS and in-hospital providers led to statistically significant reductions in D2B time and ED board time in patients with STEMI. This highlights the potential of technology-enabled communication through an integrated system to improve STEMI care and outcomes. Further research and prospective studies are needed to validate these findings and explore the optimal strategies for implementing such communication systems in different health care settings.

Declaration of competing interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethics statement and patient consent

This quality improvement project was conducted with the aim of assessing and improving our institution's door-to-balloon times using the mobile app. No interventions were introduced that could potentially harm patients, and management for all observed patients adhered to best practices based on the current literature. Patient confidentiality was strictly maintained throughout the project, and no identifiable patient information was recorded or disseminated. The study received review and approval for waiver from the Baystate Medical Center Institutional Review Board.

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