ORIGINAL RESEARCH

Regional "Call 911" Emergency Department Protocol to Reduce Interfacility Transfer Delay for Patients With ST-Segment–Elevation Myocardial Infarction

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Background—We evaluated the first-medical-contact-to-balloon (FMC2B) time after implementation of a "Call 911" protocol for ST-segment–elevation myocardial infarction (STEMI) interfacility transfers in a regional system.

Methods and Results—This is a retrospective cohort study of consecutive patients with STEMI requiring interfacility transfer from a STEMI referring hospital, to one of 35 percutaneous coronary intervention-capable STEMI receiving centers (SRCs). The Call 911 protocol allows the referring physician to activate 911 to transport a patient with STEMI to the nearest SRC for primary percutaneous coronary intervention. Patients with interfacility transfers were identified over a 4-year period (2011–2014) from a registry to which SRCs report treatment and outcomes for all patients with STEMI transported via 911. The primary outcomes were median FMC2B time and the proportion of patients achieving the 120-minute goal. FMC2B for primary 911 transports were calculated to serve as a system reference. There were 2471 patients with STEMI transferred to SRCs by 911 transport during the study period, of whom 1942 (79%) had emergent coronary angiography and 1410 (73%) received percutaneous coronary intervention. The median age was 61 years (interquartile range [IQR] 52–71) and 73% were men. The median FMC2B time was 111 minutes (IQR 88–153) with 56% of patients meeting the 120-minute goal. The median STEMI referring hospital door-in-door-out time was 53 minutes (IQR 37–89), emergency medical services transport time was 9 minutes (IQR 7–12), and SRC door-to-balloon time was 44 minutes (IQR 32–60). For primary 911 patients (N=4827), the median FMC2B time was 81 minutes (IQR 67–97).

Conclusions—Using a Call 911 protocol in this regional cardiac care system, patients with STEMI requiring interfacility transfers had a median FMC2B time of 111 minutes, with 56% meeting the 120-minute goal. **(*J Am Heart Assoc*. 2017;6:e006898. DOI: 10.1161/JAHA.117.006898.)**

Key Words: emergency medical services • interfacility transfer • ST-segment–elevation myocardial infarction

Primary percutaneous coronary intervention (PPCI) is the preferred treatment for patients with ST-segment–elevation myocardial infarction (STEMI). Regional cardiac care systems have achieved timely PPCI for patients with STEMI transported by emergency medical services (EMS) to percutaneous coronary intervention (PCI)–capable centers. More than 90% of patients who present directly to PCI-capable centers are treated within 90 minutes.[1] However, only 50% of patients with STEMI utilize EMS and nearly two thirds of hospitals in the United States lack interventional capabilities, resulting in many patients presenting to non-PCI hospitals. Therefore, establishing timely interfacility transfer (IFT) is an important aspect of a regional cardiac care system.

Transfer for PPCI within 120 minutes is feasible and improves outcomes in randomized studies as well as in individual high-performing systems.[2–7] National guidelines thus suggest that systems achieve this target metric.[8] Still, across the United States, a first-medical-contact-to-balloon (FMC2B) time within 120 minutes for transferred patients is rarely achieved. Transfer from non-PCI hospitals is strongly associated with delay to PPCI.[9] While steady progress has been made to reduce FMC2B time for patients who present directly to PCI-capable centers, progress has lagged for these

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This work was presented at the American Heart Association Resuscitation Science Symposium, November 7–11, 2015, in Orlando, FL.

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Received July 26, 2017; accepted September 11, 2017.

Clinical Perspective

What Is New?

- This study describes time to treatment in patients with ST-segment–elevation myocardial infarction transfer in a large metropolitan regionalized ST-segment–elevation myocardial infarction network utilizing a system-wide "Call 911" protocol for rapid transfer.

What Are the Clinical Implications?

- This protocol may be utilized in ST-segment–elevation myocardial infarction systems to reduce transfer delays and improve time to treatment for patients with ST-segment–elevation myocardial infarction requiring interfacility transfer.

patients with IFT.[10] National estimates for the proportion of patients with IFT receiving PPCI within 120 minutes vary widely and range from 16% to 65%.[11–13] The ability to minimize time at the transferring hospital has been demonstrated to be particularly challenging and delay in door-in-door-out (DIDO) is associated with increased mortality.[4,14]

Prior recommendations to reduce delays have included prioritizing transfer of patients with STEMI using the 911 system.[15,16] An early demonstration of this approach is the RACE (Reperfusion of Acute Myocardial Infarction in North Carolina Emergency Departments) project, which is comprised of a coordinated statewide STEMI network that preferentially uses the municipal EMS system for STEMI IFTs and redirects patients with STEMI arriving via local ambulance to a PCI-capable center without off-load at the referral facility.[17,18] This approach increased the frequency of transfer for PPCI and reduced time to reperfusion for patients with STEMI transfer.

A prior pilot study at a single PCI-capable center within the Los Angeles (LA) County regional cardiac system demonstrated the use of 911 for interfacility STEMI transfers to be both safe and feasible, resulting in a 50% reduction in median FMC2B time.[19] In the current study, we evaluated the FMC2B time for patients with STEMI after implementation of a "Call 911" protocol for STEMI IFTs across the entire regional system.

Methods

This is a retrospective cohort study of consecutive patients with STEMI requiring IFT from a non-PCI hospital or STEMI referring hospital, to one of 35 PCI-capable STEMI receiving centers (SRCs). The study was approved with exemption of informed consent by the LA Biomedical Research Institute's institutional review board.

LA County is a metropolitan area spanning 4084 square miles with over 10 million inhabitants. EMS is provided by 32 municipal fire departments, one law enforcement agency, and 25 private ambulance companies with over 3900 licensed paramedics throughout the county. The LA County EMS Agency provides oversight of providers operating within the county, establishes protocols and procedures, and designates specialty care centers.

The LA County regionalized cardiac care system consists of 35 of the 73 911 receiving hospitals designated as SRCs capable of providing immediate cardiac catheterization 24 hours per day, 7 days per week with cardiovascular surgeons available.[20] For patients with STEMI who access 911, EMS crews transport directly to the closest SRC for PPCI. For patients with STEMI identified at a non-PCI hospital, a regional Call 911 protocol was developed in 2010 to facilitate rapid transfer from the referring hospital to the nearest SRC. The Call 911 protocol involves 3 components: (1) the emergency physician at the referring hospital contacts the nearest SRC; (2) the ECG is sent electronically to the SRC; and (3) the jurisdictional 911 provider agency is called to transport the patient, unless private ambulance transport is available within 10 minutes. Patients with STEMI are transported by paramedics capable of ALS-level care, including intubation, cardiac rhythm interpretation, and defibrillation. SRCs guarantee acceptance of all patients with STEMI, regardless of hospital bed capacity. An accepting physician must be contacted and approve the transfer. Individual signed transfer agreements are also encouraged between the SRC and nearby non-PCI hospitals to facilitate the transfer process. There is no system-wide policy on emergency department (ED) bypass. The decision to transfer the patient directly to the catheterization laboratory at the SRC is made by the accepting interventionalist on an individual patient basis. At inception, system-wide education emphasized rapid identification of patients with potential STEMI, ECG acquisition within 10 minutes of initial hospital arrival, immediate ECG interpretation by the treating physician, and preparation of the patient for transport while simultaneously contacting the SRC and 911 provider. Biannual meetings are held with all system participants to discuss best practices and system improvement.

Using a standardized set of definitions, the SRCs report data on all patients with STEMI to a single registry, maintained by the LA County EMS Agency, which includes baseline demographic, clinical characteristics, processes of care, and in-hospital outcomes. Patients who are transported to the SRC for suspected STEMI are included in the registry regardless of their final diagnosis. Trained registered nurses abstract and enter patient data into a web-based data-collection tool. Completeness and accuracy of the data are continually reviewed by EMS agency staff with verification performed during site visits.

Patients 18 years or older who require IFT for STEMI were identified in the registry from 2011 through 2014. Patients were excluded if they were transported by a private ambulance service or did not receive coronary angiography and PPCI. The data were then linked, using a unique identifier, to the EMS provider database to obtain the transport time interval, which was not available in the SRC registry. Study variables included patient demographics (age, sex, race/ethnicity) and performance measures related to timeliness of PPCI (time of arrival at the referring hospital, time ECG obtained at the referring hospital, time of referring hospital departure, time of SRC arrival, time of PCI). If the referring hospital arrival time was not available in the registry, then time of initial ECG at the referring hospital was used as a proxy. If both times were missing, then that case was excluded from the analysis. In addition, data regarding whether the patient experienced out-of-hospital cardiac arrest (OHCA) were gathered, since this may affect timeliness of PPCI and selection of initial treating facility. Per LA County Protocol, patients with OHCA of presumed cardiac etiology who achieve return of spontaneous circulation are transported directly to the SRC. Intended to serve as a system reference, data were also abstracted for primary 911 transports of patients with STEMI treated with PPCI during the study period.

The primary outcomes were the median FMC2B time for patients with IFT and the proportion of patients meeting the 120-minute goal. An additional outcome was the proportion of patients with IFT treated within 90 minutes. The following time intervals were calculated: time from arrival at the referring hospital to departure (DIDO), time from departure from the referring hospital to arrival at the SRC (transport), and time from arrival at the SRC to PPCI (door-to-balloon [D2B]). All data were entered into Microsoft Excel (Microsoft Corporation) and transferred to SAS 9.4 (SAS Institute) for analysis. Time intervals are reported as medians with interquartile ranges (IQRs). A sensitivity analysis was performed excluding patients with STEMI complicated by OHCA. A linear trend in the median FMC2B time by year was assessed using the *proc glm* procedure in SAS, whereas the annual trend in the proportion of patients successfully meeting the 120-minute goal was evaluated with the Cochran-Armitage trend test.

Results

There were 2504 patients with STEMI transferred to one of 35 SRCs during the study period, of whom 2471 were transported via 911. Among transferred patients who utilized the Call 911 protocol, 1942 (79%) had emergent coronary angiography and 1410 (73%) of those patients received PPCI. Figure 1 shows the patient cohort. The median age was 61 (IQR 52–71) with 78% men (Table 1). The median FMC2B time

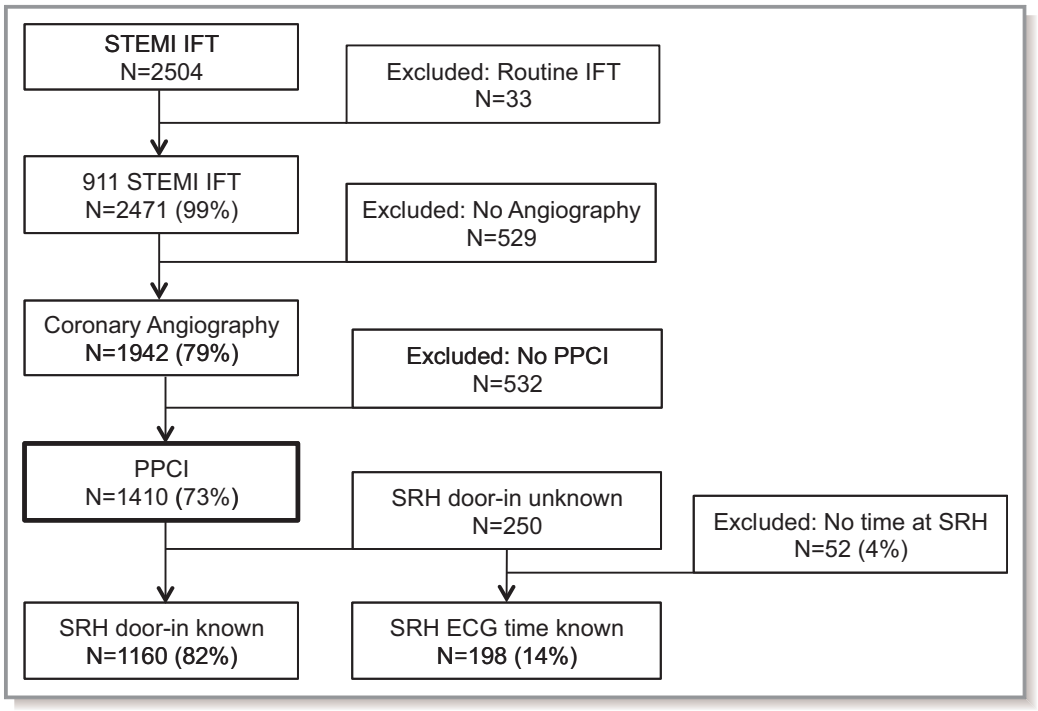

Figure 1. Patient flow diagram. IFT indicates interfacility transfer; PPCI, primary percutaneous coronary intervention; SRH, ST-segment–elevation myocardial infarction referring hospital; STEMI, ST-segment–elevation myocardial infarction.

Table 1. Patient Characteristics (N=1410)

	No.	%
Sex		
Male	1095	78
Female	308	22
Unknown	7	<1
Age, median/IQR, y	61	53–70
Race/ethnicity		
Asian	151	11
Black	86	6
Hispanic	466	33
Pacific Islander/Hawaiian	11	1
White	604	43
Other/unknown	92	7
Out-of-hospital cardiac arrest	31	2

IQR indicates interquartile range.

was 111 minutes (IQR 88–153) with 56% of patients meeting the 120-minute goal. The DIDO was the longest time interval, with a median of 53 minutes (IQR 37–89) and 14% DIDO <30 minutes. The median time from patient arrival at the referring hospital to ECG was 9 minutes (IQR 3–23). However, the mean time to ECG was 28 minutes, indicating a positive skew. Median EMS transport time was 9 minutes (IQR 7–12) and SRC D2B time was 44 minutes (IQR 32–60). Figure 2 depicts a timeline of the individual intervals and their contribution to the overall FMC2B time.

Table 2 shows the time to treatment for the STEMI IFT cohort and for the primary 911 patients in the same regional system. For primary 911 patients, the median FMC2B time was 81 minutes (IQR 67–97). While the FMC2B was shorter for primary 911 transports, the SRC D2B was longer (median time, 63 minutes; IQR 50–78). Among patients with IFT, the median time from SRC ED arrival to arrival in the catheterization laboratory was reduced compared with primary 911 transports (18 minutes [IQR 3–29] versus 35 minutes [IQR 22–48]). There were significantly more patients in the primary 911 cohort who experienced OHCA (10% versus 2% in the transferred patients). After excluding patients with OHCA, the time to treatment in each group did not change. Although there was a nonsignificant decreasing linear trend in median FMC2B time among patients with STEMI IFT (P=0.7, Figure 3), there was a significant annual trend in the proportion of transfer patients who met the 120-minute goal for FMC2B time (P=0.008).

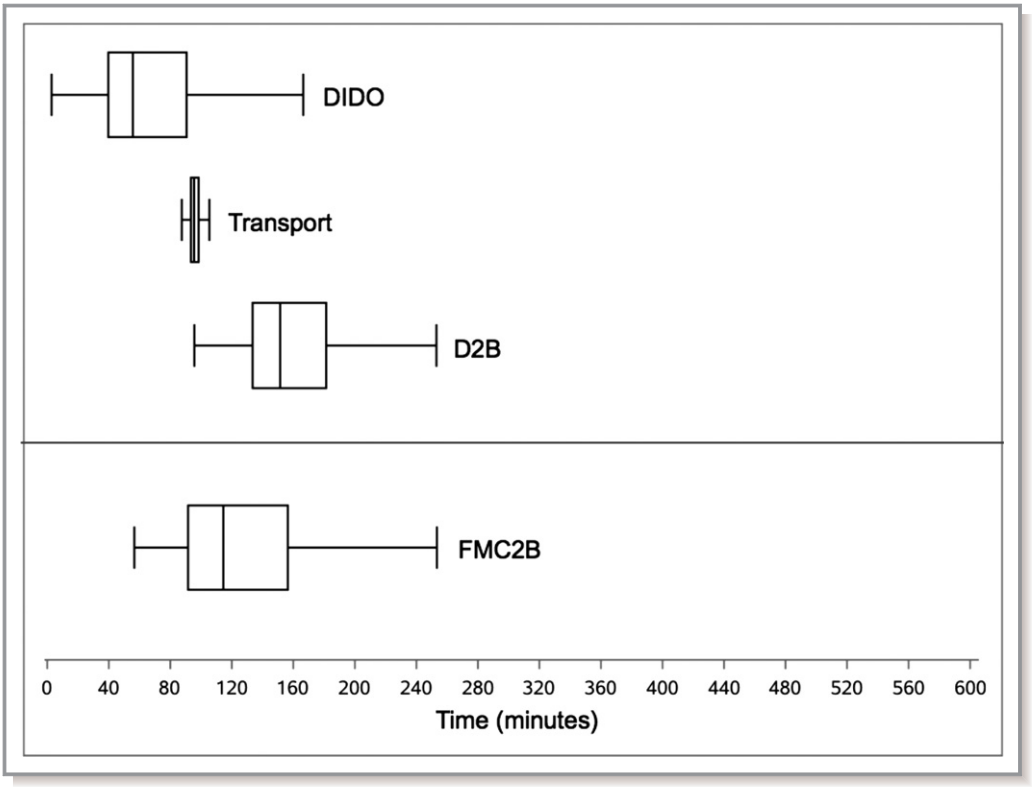

Figure 2. First-medical-contact-to-balloon (FMC2B) time by interval. D2B indicates door-to-balloon time; DIDO, door-in-door-out (time at transferring facility).

Table 2. Treatment Intervals for Patients With STEMI Who Had 911 IFT Compared With Patients With Primary 911 Transports to the SRC Treated With PCI, 2011–2014

	Transfer Patients (n=1410)		Primary 911 Patients (n=4827)	
	No.	IQR or %	No.	IQR or %
Median D2B	44	32–60	63	50–78
Median FMC2B	111	88–153	81	67–97
FMC2B <90 min	372	28	3042	68
FMC2B <120 min	754	57	4021	90

Percent of known values reported. D2B indicates door-to-balloon time; FMC2B, first-medical-contact-to-balloon time; IFT, interfacility transfer; IQR, interquartile range; PCI, percutaneous coronary intervention; SRC, ST-segment–elevation myocardial infarction receiving centers; STEMI, ST-segment–elevation myocardial infarction.

Discussion

Using a Call 911 IFT protocol for patients with STEMI, the LA County regional cardiac system achieved a median FMC2B time within national guidelines. Fifty-seven percent of transferred patients with STEMI received PCI within 120 minutes. Multiple contemporary studies suggest that <30% of patients in the United States meet this goal.[10–12,21,22] One study, which limited transport time to within 60 minutes, reported that 65% of patients were treated within 120 minutes.[13] However, these studies likely overestimate performance, given that high-performing hospitals are more likely to submit data to the national registries.[12,23] A recent evaluation in Korea demonstrated that timely treatment for STEMI IFTs remains a challenge and is not limited to the United States.[24] Lack of regional coordination and EMS use for primary transports contribute to overall delays within a STEMI system of care,[13,24,25] whereas a coordinated system can deliver timely care over considerable distances.[6,26]

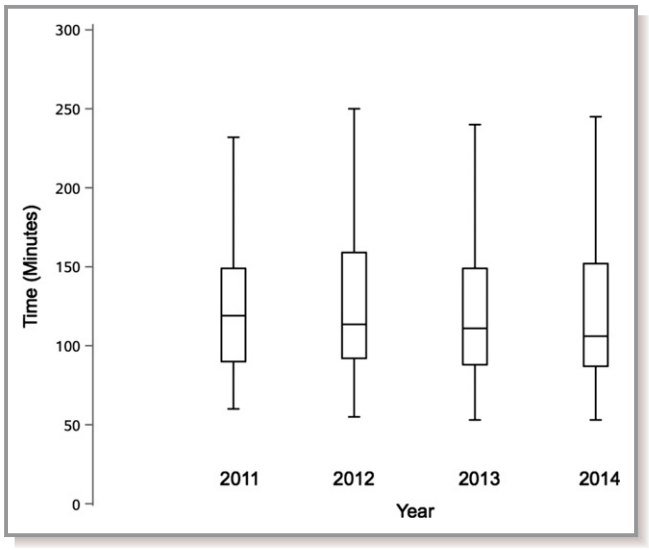

Figure 3. Annual trend in median first-medical-contact-to-balloon time for transfer patients (2011–2014). *P* for trend=0.7.

Our results support a system-wide policy of using 911 for IFT of patients with STEMI. This adds to the prior single-center pilot study that demonstrated a reduction in median FMC2B by 50%, from 167.5 to 88.5 minutes after implementation of the Call 911 protocol.[19] Similarly, Tennyson et al[27] evaluated the use of the municipal 911 ALS ambulance service compared with a contracted private ambulance service for STEMI IFTs from a single community hospital to a tertiary care center. The authors found that use of the 911 provider reduced both time from notification to ambulance arrival and time from notification to patient arrival in the catheterization laboratory, thereby concluding that use of the 911 provider reduced door-to-catheterization times.[27] The RACE program emphasized municipal EMS use for IFTs and demonstrated a significant reduction in all treatment time intervals.[17,18,28]

Evaluating the time intervals that contribute to FMC2B time (DIDO, transport, and D2B times), the longest interval was DIDO at the transferring facility. The median DIDO in our cohort was 53 minutes, with only 14% of patients achieving a DIDO of ≤30 minutes. In 2008, the American College of Cardiology (ACA) and the American Heart Association (AHA) recommended a DIDO at the transferring facility of ≤30 minutes.[21] However, this is difficult to achieve and even the best systems are achieving times of ≈45 minutes.[1] Our current results are better than the national performance data. Wang et al, using the ACTION (Acute Coronary Treatment and Intervention Outcomes Network) Registry—Get With the Guidelines, reported a median DIDO of 68 minutes and 11% of patients had a DIDO of ≤30 minutes.[14] Similarly, Herrin et al[29] found the median DIDO was 66 minutes using data reported by >1800 hospitals to the Centers for Medicare & Medicaid Services. Even in a system that achieves up to 79% FMC2B time within 120 minutes, the median DIDO was similar to our cohort at 54 minutes.[6]

Prior studies have also associated transport time with delays.[13] The median transport interval was only 9 minutes using the municipal 911 provider agency. With nearly half of all hospitals in LA County designated as SRCs, the high concentration of resources contributed to the short transport times. In addition, because of a decreased time from ED arrival to catheter laboratory arrival, the D2B time at the SRCs for transferred patients was shorter than among patients arriving by primary 911 transport. Given that these patients were already evaluated by the emergency physician at the referring hospital, expediting ED care at the SRC or even ED bypass was more likely in this group.

Given that DIDO is the biggest contributor to delay, our results suggest that improving processes at the transferring facility would be most effective to reduce time to treatment. Although potential solutions have been proposed,[25] prior

experience has shown that improving DIDO is difficult, and delay in obtaining transport is a significant contributor. Miedema et al[4] evaluated reasons for delay within each time interval. At the referral facility, the most common reason for delay was awaiting transport, affecting 26% of patients and representing 40% of all delays. Using 911 transport is one factor that has been associated with reduced DIDO.[14] For patients who initially arrive by ambulance, using the same ambulance for the IFT reduces DIDO by eliminating the wait for transporation.[25] Glickman et al[18] found that adoption of a combination of EMS processes, which included municipal ambulance use and not offloading the patient at the referral facility, was associated with the shortest median time to treatment for STEMI. After implementation of these and other interventions in North Carolina, the authors reported a median DIDO similar to ours at 58 minutes.[18] While not achieving the ACA/AHA recommendation for DIDO, the use of 911 for IFT STEMI transport in LA County system was associated with reduction in FMC2B time inclusive of this time interval. Ongoing efforts may be directed at further reducing DIDO through improvement in processes at non-PCI hospitals and coordination between the transferring and receiving facilities.

One concern may be the burden these additional calls could have on the 911 provider agency and the SRC, particularly if the false activation rate is high or the availability of 911 leads to inappropriate use for nonemergent transfers. In this cohort, 80% of patients received emergent coronary angiography. Of the patients who did not receive emergent coronary angiography, the procedure was deemed not indicated in 82%, whereas 9% had a contraindication or refusal, 2% died before the procedure. The reason was unknown in 7%. While these patients did not benefit from the intended intervention, and therefore represent "false-positives," the burden on the system is low, amounting to 1 patient every 3 months per SRC. Further, it is not known whether this frequency is related to the use of 911. Current data suggest that participating in IFTs is not likely to be a significant burden on the 911 provider. In a review of 7 years of IFTs completed by the LA Fire Department, Eckstein et al[30] found that IFTs represented <0.1% of calls, with an average total call time of 51 minutes, and <5% of IFTs were deemed to be potentially inappropriate 911 use.

As has been noted by prior authors, the use of 911 to reduce IFT delays highlights the importance of collaboration and coordination between all system participants to ensure timely care for patients with STEMI. The Cardiac Care Network of Ontario implemented a similar approach to EMS use for STEMI IFTs. In their consensus report, the authors specify that EMS is a "critical infrastructure requirement to ensure timely, reliable and appropriate transportation of the acute MI patient" and that "improvements in both the interfaciity transfers and repatriation process would be required."[31] No one entity is responsible for the FMC2B time, since it involves multiple time intervals, reliant on a coordinated system of care. In regional systems of care, awaiting a transport resource can result in unacceptable delays for time-critical emergencies.[32,33] The mortality benefit of transfer for PPCI compared with fibrinolysis is limited to 120 minutes, and delays in transport can result in an inability to provide this preferred treatment within the recommended timeframe. The use of 911 for STEMI IFTs increases the availability of PPCI for the patients the regional system is there to serve.

Study Limitations

The biggest limitation to this study is lack of prior comparative data. The EMS system did not collect data on timing of IFTs prior to implementing the Call 911 protocol, so the direct impact of this protocol on time to treatment for patients with STEMI requiring IFT in the system cannot be calculated. Primary 911 transports are inherently different and cannot serve as a direct comparison. Twenty percent of patients transferred did not receive PPCI, and transfer times for these patients are not included in the study results. We are not able to evaluate any association between transfer modality and the frequency of transfers that do not receive the intended intervention. There was a significant percentage of patients with missing data on arrival time at the referral facility. All patient data are entered by the SRCs and these data were not always available. Use of the time of the initial ECG as a surrogate results in an underestimation of the FMC2B time in those patients. In addition, there are unmeasured confounding variables. Given the retrospective nature of the study and the limitations of the data registry, reasons for individual patient-related and system-related delays are unknown. The reason for the delay may be more important than the length of delay in regard to patient outcomes.[4] Finally, LA County is primarily urban-suburban, and therefore these results may not be generalizable to rural areas, where transport times are longer.

Conclusions

Using a Call 911 protocol in this regional cardiac care system, patients with STEMI requiring IFT had a median FMC2B time of 111 minutes, with 56% meeting the 120-minute goal.

Acknowledgments

The authors would like to thank all of the SRC participants and the LA County EMS Agency staff, in particular Christine Clare, RN, Paula Rashi, RN, and Richard Tadeo, RN, who contributed to the patient registry and whose dedicated work provided the necessary data for this analysis.

Disclosures

None.

References

1. Bates ER, Jacobs AK. Time to treatment in patients with STEMI. *N Engl J Med*. 2013;369:889–892.
2. Cannon CP, Gibson CM, Lambrew CT, Shoultz DA, Levy D, French WJ, Gore JM, Weaver WD, Rogers WJ, Tiefenbrunn AJ. Relationship of symptom-onset-to-balloon time and door-to-balloon time with mortality in patients undergoing angioplasty for acute myocardial infarction. *JAMA*. 2000;283:2941–2947.
3. Pinto DS, Frederick PD, Chakrabarti AK, Kirtane AJ, Ullman E, Dejam A, Miller DP, Henry TD, Gibson CM; National Registry of Myocardial Infarction Investigators. Benefit of transferring ST-segment-elevation myocardial infarction patients for percutaneous coronary intervention compared with administration of onsite fibrinolytic declines as delays increase. *Circulation*. 2011;124:2512–2521.
4. Miedema MD, Newell MC, Duval S, Garberich RF, Handran CB, Larson DM, Mulder S, Wang YL, Lips DL, Henry TD. Causes of delay and associated mortality in patients transferred with ST-segment-elevation myocardial infarction. *Circulation*. 2011;124:1636–1644.
5. Andersen HR, Nielsen TT, Rasmussen K, Thuesen L, Kelbaek H, Thayssen P, Abildgaard U, Pedersen F, Madsen JK, Grande P, Villadsen AB, Krusell LR, Haghfelt T, Lomholt P, Husted SE, Vigholt E, Kjaergard HK, Mortensen LS; Investigators D-. A comparison of coronary angioplasty with fibrinolytic therapy in acute myocardial infarction. *N Engl J Med*. 2003;349:733–742.
6. Henry TD, Sharkey SW, Burke MN, Chavez IJ, Graham KJ, Henry CR, Lips DL, Madison JD, Menssen KM, Mooney MR, Newell MC, Pedersen WR, Poulose AK, Traverse JH, Unger BT, Wang YL, Larson DM. A regional system to provide timely access to percutaneous coronary intervention for ST-elevation myocardial infarction. *Circulation*. 2007;116:721–728.
7. Munoz D, Roettig ML, Monk L, Al-Khalidi H, Jollis JG, Granger CB. Transport time and care processes for patients transferred with ST-segment-elevation myocardial infarction: the reperfusion in acute myocardial infarction in Carolina emergency rooms experience. *Circ Cardiovasc Interv*. 2012;5:555–562.
8. Levine GN, Bates ER, Blankenship JC, Bailey SR, Bittl JA, Cercek B, Chambers CE, Ellis SG, Guyton RA, Hollenberg SM, Khot UN, Lange RA, Mauri L, Mehran R, Moussa ID, Mukherjee D, Nallamothu BK, Ting HH. 2011 ACCF/AHA/SCAI guideline for percutaneous coronary intervention: executive summary: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions. *Circulation*. 2011;124:2574–2609.
9. Angeja BG, Gibson CM, Chin R, Frederick PD, Every NR, Ross AM, Stone GW, Barron HV; Participants in the National Registry of Myocardial Infarction 2-3. Predictors of door-to-balloon delay in primary angioplasty. *Am J Cardiol*. 2002;89:1156–1161.
10. Wang TY, Peterson ED, Ou FS, Nallamothu BK, Rumsfeld JS, Roe MT. Door-to-balloon times for patients with ST-segment elevation myocardial infarction requiring interhospital transfer for primary percutaneous coronary intervention: a report from the National Cardiovascular Data Registry. *Am Heart J*. 2011;161:76–83.e1.
11. Nallamothu BK, Bates ER, Herrin J, Wang Y, Bradley EH, Krumholz HM; NRMI Investigators. Times to treatment in transfer patients undergoing primary percutaneous coronary intervention in the United States: National Registry of Myocardial Infarction (NRMI)-3/4 analysis. *Circulation*. 2005;111:761–767.
12. Chakrabarti A, Krumholz HM, Wang Y, Rumsfeld JS, Nallamothu BK; National Cardiovascular Data R. Time-to-reperfusion in patients undergoing interhospital transfer for primary percutaneous coronary intervention in the U.S: an analysis of 2005 and 2006 data from the National Cardiovascular Data Registry. *J Am Coll Cardiol*. 2008;51:2442–2443.
13. Dauerman HL, Bates ER, Kontos MC, Li S, Garvey JL, Henry TD, Manoukian SV, Roe MT. Nationwide analysis of patients with ST-segment-elevation myocardial infarction transferred for primary percutaneous intervention: findings from the American Heart Association Mission: Lifeline Program. *Circ Cardiovasc Interv*. 2015;8:e002450.
14. Wang TY, Nallamothu BK, Krumholz HM, Li S, Roe MT, Jollis JG, Jacobs AK, Holmes DR, Peterson ED, Ting HH. Association of door-in to door-out time with reperfusion delays and outcomes among patients transferred for primary percutaneous coronary intervention. *JAMA*. 2011;305:2540–2547.
15. Ellrodt G, Sadwin LB, Aversano T, Brodie B, O'Brien PK, Gray R, Hiratzka LF, Larson D. Development of systems of care for ST-elevation myocardial infarction patients: the non-percutaneous coronary intervention-capable (ST-elevation myocardial infarction referral) hospital perspective. *Circulation*. 2007;116:e49–e54.
16. Jollis JG, Mehta RH, Roettig ML, Berger PB, Babb JD, Granger CB. Reperfusion of acute myocardial infarction in North Carolina emergency departments (RACE): study design. *Am Heart J*. 2006;152:851.e1–11.
17. Jollis JG, Roettig ML, Aluko AO, Anstrom KJ, Applegate RJ, Babb JD, Berger PB, Bohle DJ, Fletcher SM, Garvey JL, Hathaway WR, Hoekstra JW, Kelly RV, Maddox WT Jr, Shiber JR, Valeri FS, Watling BA, Wilson BH, Granger CB; Reperfusion of Acute Myocardial Infarction in North Carolina Emergency Departments I. Implementation of a statewide system for coronary reperfusion for ST-segment elevation myocardial infarction. *JAMA*. 2007;298:2371–2380.
18. Glickman SW, Lytle BL, Ou FS, Mears G, O'Brien S, Cairns CB, Garvey JL, Bohle DJ, Peterson ED, Jollis JG, Granger CB. Care processes associated with quicker door-in-door-out times for patients with ST-elevation-myocardial infarction requiring transfer: results from a statewide regionalization program. *Circ Cardiovasc Qual Outcomes*. 2011;4:382–388.
19. Baruch T, Rock A, Koenig WJ, Rokos I, French WJ. "Call 911" STEMI protocol to reduce delays in transfer of patients from non primary percutaneous coronary intervention referral centers. *Crit Pathw Cardiol*. 2010;9:113–115.
20. Eckstein M, Koenig W, Kaji A, Tadeo R. Implementation of specialty centers for patients with ST-segment elevation myocardial infarction. *Prehosp Emerg Care*. 2009;13:215–222.
21. Krumholz HM, Anderson JL, Bachelder BL, Fesmire FM, Fihn SD, Foody JM, Ho PM, Kosiborod MN, Masoudi FA, Nallamothu BK; American College of Cardiology/American Heart Association Task Force on Performance Measures, American Academy of Family Physicians, American College of Emergency Physicians, American Association of Cardiovascular and Pulmonary Rehabilitation, Society for Cardiovascular Angiography and Interventions, Society of Hospital Medicine. ACC/AHA 2008 performance measures for adults with ST-elevation and non-ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Performance Measures (Writing Committee to develop performance measures for ST-elevation and non-ST-elevation myocardial infarction): developed in collaboration with the American Academy of Family Physicians and the American College of Emergency Physicians: endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation, Society for Cardiovascular Angiography and Interventions, and Society of Hospital Medicine. *Circulation*. 2008;118:2596–2648.
22. Fosbol EL, Granger CB, Peterson ED, Lin L, Lytle BL, Shofer FS, Lohmeier C, Mears GD, Garvey JL, Corbett CC, Jollis JG, Glickman SW. Prehospital system delay in ST-segment elevation myocardial infarction care: a novel linkage of emergency medicine services and in hospital registry data. *Am Heart J*. 2013;165:363–370.
23. Roe MT, Messenger JC, Weintraub WS, Cannon CP, Fonarow GC, Dai D, Chen AY, Klein LW, Masoudi FA, McKay C, Hewitt K, Brindis RG, Peterson ED, Rumsfeld JS. Treatments, trends, and outcomes of acute myocardial infarction and percutaneous coronary intervention. *J Am Coll Cardiol*. 2010;56:254–263.
24. Park JH, Ahn KO, Shin SD, Cha WC, Ryoo HW, Ro YS, Kim T. The first-door-to-balloon time delay in STEMI patients undergoing interhospital transfer. *Am J Emerg Med*. 2016;34:767–771.
25. Lambert LJ, Brown KA, Boothroyd LJ, Segal E, Maire S, Kouz S, Ross D, Harvey R, Rinfret S, Xiao Y, Nasmith J, Bogaty P. Transfer of patients with ST-elevation myocardial infarction for primary percutaneous coronary intervention: a province-wide evaluation of "door-in to door-out" delays at the first hospital. *Circulation*. 2014;129:2653–2660.
26. Minha S, Loh JP, Satler LF, Pendyala LK, Barbash IM, Magalhaes MA, Suddath WO, Pichard AD, Torguson R, Waksman R. Transfer distance effect on reperfusion: timeline of ST-elevation patients transferred for primary percutaneous coronary intervention. *Cardiovasc Revasc Med*. 2014;15:369–374.
27. Tennyson JC, Quale MR. Reduction in STEMI transfer times utilizing a municipal "911" ambulance service. *Prehosp Disaster Med*. 2014;29:50–53.
28. Jollis JG, Al-Khalidi HR, Monk L, Roettig ML, Garvey JL, Aluko AO, Wilson BH, Applegate RJ, Mears G, Corbett CC, Granger CB; Regional Approach to Cardiovascular Emergencies I. Expansion of a regional ST-segment-elevation myocardial infarction system to an entire state. *Circulation*. 2012;126:189–195.
29. Herrin J, Miller LE, Turkmani DF, Nsa W, Drye EE, Bernheim SM, Ling SM, Rapp MT, Han LF, Bratzler DW, Bradley EH, Nallamothu BK, Ting HH, Krumholz HM. National performance on door-in to door-out time among patients transferred for primary percutaneous coronary intervention. *Arch Intern Med*. 2011;171:1879–1886.
30. Eckstein M, Schlesinger SA, Sanko S. Interfacility transports utilizing the 9-1-1 emergency medical services system. *Prehosp Emerg Care*. 2015;19:490–495.

31. Labinaz M, Swabey T, Watson R, Natarajan M, Fucile W, Lubelsky B, Sawadsky B, Cohen E, Glasgow K; CCN Consensus Panel on Access to Urgent PCI for ST Segment Elevation Myocardial Infarction. Delivery of primary percutaneous coronary intervention for the management of acute ST segment elevation myocardial infarction: summary of the Cardiac Care Network of Ontario Consensus Report. *Can J Cardiol*. 2006;22:243–250.

32. Hill AD, Fowler RA, Nathens AB. Impact of interhospital transfer on outcomes for trauma patients: a systematic review. *J Trauma*. 2011;71:1885–1900; discussion 1901.

33. Harrington DT, Connolly M, Biffl WL, Majercik SD, Cioffi WG. Transfer times to definitive care facilities are too long: a consequence of an immature trauma system. *Ann Surg*. 2005;241:961–966; discussion 966–968.