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Original Contributions

THE OUTCOMES OF EMERGENCY PHARMACIST PARTICIPATION DURING ACUTE MYOCARDIAL INFARCTION

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☐ **Abstract—Background: Current guidelines recommend door-to-balloon times of 90 min or less for patients presenting to the emergency department (ED) with ST-segment elevation myocardial infarction (STEMI). Objectives: To determine if a clinical pharmacist for the ED (EPh) is associated with decreased door/diagnosis-to-cardiac catheterization laboratory (CCL) time and decreased door-to-balloon time. Methods: A retrospective observational cohort study of ED patients with STEMI requiring urgent cardiac catheterization was conducted. Blinded data collection included timing of ED and CCL arrival, diagnostic electrocardiogram (ECG), and balloon angioplasty. For cases diagnosed after ED arrival, diagnosis time was substituted for door time. Diagnosis was the time ST elevations were evident on serial ECG. EPh present and not-present groups were compared. During the study period there were two EPhs and presence was determined by their scheduled time in the ED. Univariate and multivariate analyses was used to detect differences. Results: Multivariate analysis of 120 patients, controlled for CCL staff presence and arrival by pre-hospital services, determined that EPh presence is associated with a mean 13.1-min (95% confidence interval [CI] 6.5–21.9) and 11.5-min (95% CI 3.9–21.5) decrease in door/diagnosis-to-CCL and door-to-balloon times, respectively. Patients were more likely to achieve a door/diagnosis-to-CCL time ≤ 30 min (odds ratio [OR] 3.1, 95% CI 1.3–7.8) and ≤ 45 min (OR 2.9, 95% CI–1.0, 8.5) and a door-to-balloon time ≤ 90 min (OR 1.9, 95% CI 0.7–5.5) more likely when the EPh was present. Conclusions: EPh presence during STEMI presentation to the ED is independently associated with a decrease in door/diagnosis-to-CCL and door-to-balloon times.**

☐ **Keywords—pharmacist; acute myocardial infarction; ST-segment myocardial infarction; STEMI; door-to-balloon time**

INTRODUCTION

Medication errors and drug-related adverse events are a significant concern in the emergency department (ED) (1). This setting is particularly vulnerable to these therapeutic misadventures owing to several facets of practice in this environment (2–4). Specifically, this is characterized by the high prevalence of verbal orders, frequent use of high-risk intravenous medications, lack of prospective pharmacy review before medication dispensing, and frequent provider interruptions as a result of high patient volumes. Published reports have documented the value of clinical pharmacy services in the ED, which has lead to

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the initiation of several Emergency Medicine Clinical Pharmacy Programs (5–9). Initial analyses have shown that these practitioners significantly contribute to ED services by performing numerous interventions and decreasing overall medication costs (10,11). The impact of the dedicated emergency clinical pharmacist (EPh) on clinical outcomes, however, is not as well described.

In a retrospective study performed at our institution, the participation of the EPh in trauma resuscitation was associated with a decrease in time to medication delivery and administration and time to rapid sequence intubation, as well as a decrease in adverse drug events, potential adverse drug events, and problem drug orders (12). The role of the EPh during acute myocardial infarction (AMI) is similar to that in trauma resuscitation and includes gathering patient-specific information (weight, past medication history, and allergies), evaluating appropriate medications and medication doses for each patient, facilitating medication administration (obtaining medication from the automated dispensing cabinet and the central pharmacy as well as programming the medication infusion pumps), and preventing adverse drug events and potential adverse drug events. At the time of the study, medication preparation in the ED for patients going for urgent cardiac catheterization included aspirin, sublingual nitroglycerin, clopidogrel, and intravenous heparin, glycoprotein IIb/IIIa inhibitor, and metoprolol. When the EPh is not present in the ED, medications are obtained by the nurse from the automated medication dispensing cabinet or from the central pharmacy.

Primary percutaneous coronary intervention (PCI) remains the first treatment of choice among ST-segment elevation myocardial infarction (STEMI) patients. Based on the accepted concept of “time is myocardium,” it is essential to ensure the shortest possible time from medical contact to PCI. The American College of Cardiology/American Heart Association guidelines for the management of patients presenting with STEMI recommend door-to-balloon time of 90 min or less (13). Longer door-to-balloon times have been associated with an increased in-hospital and late mortality (14–16).

The purpose of this study was to determine if the presence of an EPh during STEMI patient presentation and evaluation decreased time in the ED, described as door/diagnosis-to-cardiac catheterization laboratory (CCL) time and, ultimately, door-to-balloon time. We hypothesized that these key time intervals would be reduced by the presence of the EPh.

MATERIALS AND METHODS

Study Design

This was a retrospective observational study of the outcomes of EPh participation during STEMI patient presentation to the ED. We tested the null hypothesis that the involvement of a dedicated emergency medicine pharmacist would not improve time in the ED or door-to-balloon time in patients presenting with STEMI and subsequent urgent cardiac catheterization. Approval for this study was obtained from the institutional review board.

Study Setting and Population

This study was conducted in the ED of a 735-bed university teaching hospital from August 15, 2005 through August 15, 2006. Our institution is a regional cardiac catheterization center that services over 100 AMI patients undergoing primary PCI per year. A protocol of out-of-hospital electrocardiogram (ECG) and diversion to our center was in place during the study period. Patients that arrived without emergency medical services received an ECG at triage. Upon arrival and triage, the emergency physician conducts the initial evaluation of the patient, determines the need for AMI team activation, and orders the necessary medications per protocol. The AMI team, consisting of the Cardiology fellow or attending determines the need for primary PCI and activation of the CCL team.

The EPh has been involved in AMI patient evaluation since 2000 when dedicated EPh services were introduced to our ED. The EPh is present for all possible STEMI evaluation or responds to all overhead AMI team activation calls if they are in the ED or elsewhere in the hospital. The time period of the study was chosen because there were 2 dedicated EPhs, scheduled separately, at both varying hours (day, evening, and night) and days (weekday and weekend), encompassing approximately 80 h per week at this time.

Patients were captured by retrospective review from an existing, institutional quality assurance database. This database contains patients with an STEMI who presented to the ED and required urgent cardiac catheterization in the CCL. Additionally, the database includes the time of arrival to the ED, time of the first ECG, time of arrival in the CCL, and the time of balloon angioplasty. Patients were included if they were assessed by the AMI team in the ED and underwent subsequent urgent cardiac catheterization. Patients transferred from another institution for primary PCI, transferred directly to the CCL (bypassing the ED), or transferred directly from the ED to the operating room for coronary artery bypass graft (CABG) surgery were excluded. Furthermore, patients experiencing transient ventricular fibrillation (VF) arrest in the ED before transfer to the CCL or those that had a delayed diagnosis in the ED were excluded.

Study Protocol

A complete medical record review, including available electronic databases, was conducted by one abstractor using a standardized abstraction form and code book to gather demographics and TIMI (Thrombolysis in Myocardial Infarction) risk factors, means of arrival to the ED, time and day of arrival to the ED, diagnostic ECG, arrival to the CCL, and balloon angioplasty (17). All times collected by chart review were verified with the quality assurance database previously described. Conflicting data between the database and chart review were resolved by accepting the door time from the emergency medical services (EMS) record, ECG time from an electronic ECG database, arrival to CCL and balloon times from the separate cardiac catheterization report located in the patient chart. Furthermore, an inter-rater reliability assessment from a sample of 25% of included patients deemed data collection 100% reliable. Data recorded during the inter-rater reliability assessment included all time-dependent endpoints; time of arrival to the ED, diagnostic ECG, arrival to the CCL, and balloon angioplasty. Reliability in eligibility was not evaluated.

To minimize bias, all data collection was completed before the determination of study group (EPh present or EPh not present). The presence of the EPh was identified from records of an existing database for an ongoing EPh study (Agency for Healthcare Research and Quality grant: U18 HS015818) and further verified by a cross check of records from the automated medication dispensing cabinet. Documentation that the EPh removed at least one medication from the automated dispensing cabinet was used to verify EPh involvement with each specific patient. There were conflicting data in 6 patients. Specifically, the EPh had removed medication from the automated dispensing cabinet during a time outside of their scheduled shift. In these cases, the EPh was regarded as present. Conversely, there were no cases when the EPh was scheduled but did not remove medication.

To accurately capture the time the EPh was involved in patient care and therefore able to affect outcome, an adjusted parameter, door/diagnosis time, was developed and used in the analysis. When STEMI was identified by diagnostic ECG in the pre-hospital setting, the door/diagnosis time was the time that the patient entered the ED. When STEMI was identified in the ED, the door/diagnosis time was the time of the first diagnostic ECG. Time endpoints, door-to-CCL and door-to-balloon times, were analyzed as both continuous and dichotomous variables (door/diagnosis-to-CCL time ≤ 30 and 45 min and door-to-balloon time ≤ 90 min). Door/diagnosis-to-CCL was dichotomized as such based on the mean time of 35 min from arrival at CCL to balloon angioplasty at our institution. Therefore, if we can get patients transferred out of the ED within 45 min, the time endpoint of door-to-balloon ≤ 90 min would have a greater possibility of being achieved. Remaining consistent with the concept of "time equals myocardium," we further dichotomized this endpoint to investigate ≤ 30 min.

To consider the differences for day vs. evening and weekend hours we determined from the ED Nurse Manager that there is no difference in the nursing staff in the trauma/critical care area throughout these times. At our institution, STEMI patients are triaged to the trauma/critical care area from EMS or transferred to the trauma/critical care area once STEMI is identified in the ED. Nurses are generally shifted from other areas to the trauma/critical care area if needed for a high volume of patients. It is well accepted that the evening and weekend times in the ED are generally of higher volume, consequently, we did categorize patients for presentation during the daytime and weekday hours (Monday–Friday, 8:00 a.m.–3:59 p.m.) or combined evening hours (Monday–Friday, 4:00 p.m.–7:59 a.m.) and weekend days/hours (Saturday–Sunday). It was determined as well that the presence of the CCL staff between day (staff present) and evenings and weekends (staff on call) would likely be a potential confounder. The staffing schedule (Monday–Friday, 7:00 a.m.–7:00 p.m.) was thus obtained from the CCL nurse manager, and all patients were categorized as having the CCL present or on call at the time of AMI team activation.

Data Analysis

Associations between continuous and categorical variables were assessed using the Wilcoxon rank-sum test and chi-squared analysis, respectively. Independent variables with a $p \leq 0.2$ were entered into multivariate linear regression models for the continuous endpoints and multivariate logistic regression models for the categorical endpoints. We looked at the outcome measures by both linear and logistic regression. Because both outcome variables were not normally distributed, we did a logarithmic data transformation using base-10 logs to obtain a "normal" distribution of the data for the linear regression models. The results from the linear regression were then back-transformed to minutes in the original scale. All statistical tests were completed using SigmaStat (version 2.0, Systat Software Inc., San Jose, CA) and SAS (version 9.2, SAS Institute Inc., Cary, NC). Statistical significance was defined as a p-value ≤ 0.05.

RESULTS

A total of 135 patients were identified during the study period. Fifteen patients were excluded: 8 patients were transferred directly from EMS to the CCL, 4 patients experienced transient VF arrest in the ED, one patient was transferred directly to the operating room for CABG, one patient with a STEMI diagnosed by EMS that resolved in the ED and the patient later went for angiography, and in one patient that presented with J-point elevations, serial ECGs were performed, and the patient later went for angiography (Figure 1). There were 120 patients included in the analysis: 52 patients where the EPh was present and 68 patients where the EPh was not present (Figure 1). One patient went to the CCL but was transferred to the operating room for CABG and balloon angioplasty was not performed. This patient was excluded from the door-to-balloon analysis. Baseline characteristics were similar between the groups, with the exception of arrival to the ED by EMS, CCL staff present at AMI team activation, and patient presentation during daytime hours (Table 1).

Analysis was performed to assess the relationship of EPh presence, CCL presence, arrival by EMS, and presentation during daytime hours. EPh presence decreased the median door/diagnosis-to-CCL time (22 vs. 40 min) and the median door-to-balloon time (59 vs. 87 min) (Figure 2). Additionally, there was a difference in all time-interval endpoints when analyzing CCL staff presence (n = 52) vs. on call (n = 68), arrival by EMS (n = 87) vs. self (n = 33), and presentation during daytime (n = 39) vs. evenings/weekends (n = 81) (Figure 2).

To assess the effect of CCL presence on our results, we compared the mean door/diagnosis-to-CCL time with and without EPh presence for patients that presented at times for both CCL present and CCL on call. For each of these groups, there was a significantly shorter time to CCL with EPh presence ($p = 0.02$). Furthermore, the Pearson correlation coefficient was calculated to detect any multicollinearity among the variables. Presence of the CCL staff and patient presentation during daytime hours were highly correlated ($r = 0.72$). Separate linear and logistic regression models were evaluated and it was determined that including CCL staff presence was a better fit.

Multivariate linear regression analysis was performed and included EPh presence or not and these two potential confounders to control for the potential bias from the CCL staff status and arrival status. The analysis showed that EPh presence was independently associated with a mean 13.1-min (95% confidence interval [CI] 6.5–21.9) decrease in door/diagnosis-to-CCL time and a mean 11.5-min (95% CI 3.9–21.5) decrease in door-to-balloon time (Table 2). Multivariate logistic regression analysis was performed using the confounders of CCL presence and arrival by EMS. Patients were more likely to achieve a door/diagnosis-to-CCL time ≤ 30 min (odds ratio [OR] 3.1, 95% CI 1.3–7.8) and ≤ 45 min (OR 2.9, 95% CI 1.0–8.5) when the EPh was present. In the EPh present and not-present groups, 42/52 (80.7%) and 36/67 (53.7%) patients, respectively, achieved door-to-balloon times ≤ 90 min. However, EPh presence was not independently associated with the proportion of patients achieving a door-to-balloon time ≤ 90 min after multivariate analysis (OR 1.9; 95% CI 0.7–5.5) (Table 3).

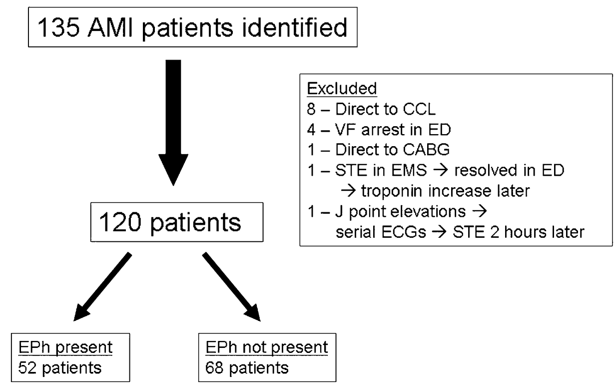

Figure 1. Study sample. AMI = acute myocardial infarction; CABG = coronary artery bypass graft; CCL = cardiac catheterization laboratory; ECG = electrocardiogram; ED = emergency department; EMS = emergency medical services; EPh = emergency pharmacist; STE = ST-elevation; VF = ventricular fibrillation.

Table 1. Demographic Characteristics of Study Patients at Presentation

	EPh Present (n = 52)	EPh Not Present (n = 68)
Age, mean years (SD)	56.5 (12.0)	59.1 (12.6)
Male (%)	40 (76.9)	50 (73.5)
Hypertension (%)	21 (40.4)	35 (51.5)
Diabetes mellitus (%)	8 (15.4)	15 (22.1)
Coronary artery disease (%)	13 (25.0)	14 (20.6)
Systolic blood pressure < 100 mm Hg (%)	7 (13.5)	7 (10.3)
Heart rate > 100 beats/min (%)	1 (1.9)	4 (5.9)
Weight < 67 kg (%)	8 (15.4)	7 (10.3)
Anterior ST elevation or LBBB (%)	16 (30.8)	22 (32.4)
Arrival to the ED by EMS (%)	44 (84.6)	43 (63.2)
CCL staff present (%)	34 (65.4)	18 (26.5)
Daytime presentation (%)	26 (50.0)	13 (19.1)

EPh = emergency pharmacist; LBBB = left bundle branch block; ED = emergency department; EMS = emergency medical services; CCL = cardiac catheterization laboratory.

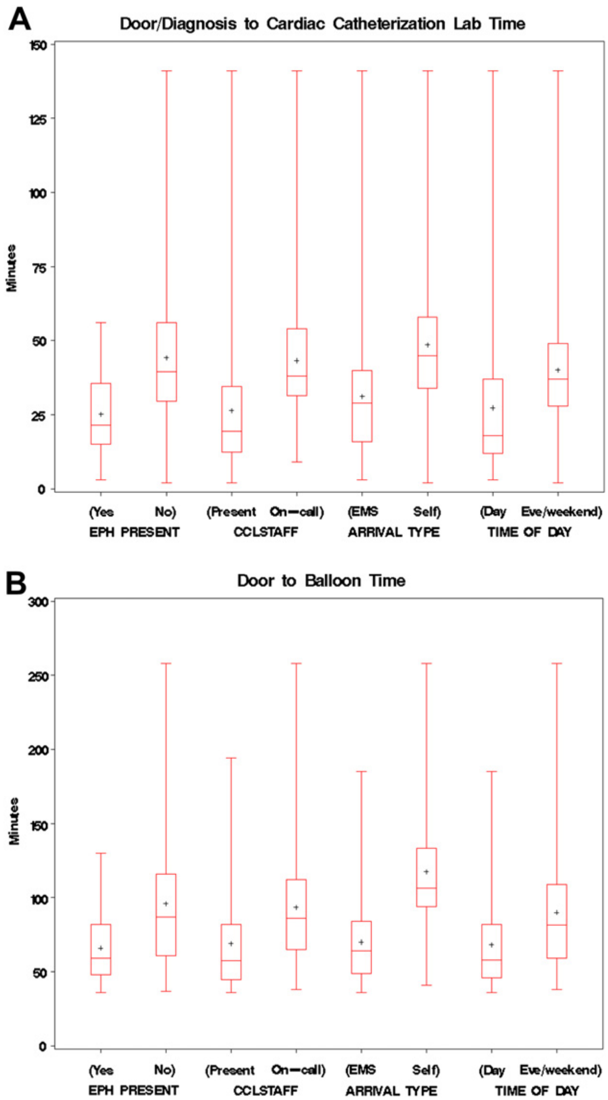

Figure 2. (A) Univariate analysis of door/diagnosis-to-CCL time. (B) Univariate analysis of door-to-balloon time. CCL = cardiac catheterization laboratory; EMS = emergency medical services; EPh = emergency pharmacist.

DISCUSSION

The role of the hospital pharmacist has evolved into one that involves active prevention of medication errors, in part by screening provider orders for accuracy in dose, drug interactions, contraindications, and allergies. Multiple studies have shown the positive impact a clinical pharmacist has on patient care in the critical care setting (18–20). A study evaluating the effects of pharmacist participation on intensive care unit rounds found a 66% reduction in preventable adverse drug events (18). Brent and Poltorak documented the services that a clinical pharmacist can provide as a member of the trauma team, in both the acute and follow-up phases of care (5). Several studies have described the value of a dedicated clinical pharmacist in the ED through survey data and documentation of interventions, but few studies have addressed outcomes data in regards to the EPh (10–12,21,22).

In 1999, the time required to perform direct coronary angioplasty and its relationship with mortality was evaluated in a prospective substudy of the GUSTO-IIb trial (14). The 30-day mortality rate of patients who underwent balloon angioplasty ≤ 60 min, 61–75 min, 76–90 min, and ≥ 91 min from randomization was 1%, 3.7%, 4.0%, and 6.4%, respectively. Further analysis revealed that the risk of death increased 1.6 times ($p = 0.008$) for a movement from each time interval to the next (14). Rathore et al. report a 4.6% overall in-hospital mortality in a recent prospective cohort study of 43,801 patients presenting with STEMI that subsequently underwent primary PCI (16). Patients who died were found to have a median 14 min longer door-to-balloon time than those who survived, 96 vs. 82 min, $p < 0.001$. Furthermore, multivariate regression models indicate that longer door-to-balloon times were associated with a higher adjusted in-hospital mortality, 30 min = 3%, 60 min = 3.5%, 90 min = 4.3%, 120 min = 5.6%, 150 min = 7%, 180 min = 8.4%; $p < 0.001$ for the trend (16). Additionally, prolonged door-to-balloon time was an independent predictor for both in-hospital and late mortality in a study of 2322 consecutive patients (23). These findings further illustrate the need to minimize door-to-balloon time to the greatest extent beyond the accepted 90-min endpoint.

In our study, we assumed that the EPh has the most impact from the time the patient either entered the ED with a pre-hospital diagnostic ECG or received a diagnosis of an STEMI in the ED based on ECG (door/diagnosis) to the time the patient arrived in the CCL. The EPh is not able to affect the time from arrival to the CCL to balloon

Table 2. Multivariate Linear Regression Analysis

	Mean Door/Diagnosis-to-CCL Time (n = 120)	Mean Door-to-Balloon Time (n = 119)*
EPh present, min (95% CI) *p*-value	13.1 (6.5–21.9) 0.0324	11.5 (3.9–21.5) 0.0487
CCL present, min (95% CI) *p*-value	17.6 (13.4–25.4) < 0.0001	12.8 (6.7–22.9) 0.0003
Arrival by EMS, min (95% CI) *p*-value	14.8 (9.3–23.2) 0.0029	16.1 (12.2–26.1) < 0.0001

CCL = cardiac catheterization laboratory; EPh = emergency pharmacist; CI = confidence interval; EMS = emergency medical services.
* One patient was transferred from the cardiac catheterization laboratory to the operating room for coronary artery bypass graft before balloon angioplasty.

Table 3. Multivariate Logistic Regression Analysis

	Door/Diagnosis-to-CCL Time ≤ 30 Minutes (n = 120) Odds Ratio (95% CI)	Door/Diagnosis-to-CCL Time ≤ 45 Minutes (n = 120) Odds Ratio (95% CI)	Door-to-Balloon Time ≤ 90 Minutes (n = 119)* Odds Ratio (95% CI)
EPh present	3.1 (1.3–7.8)	2.9 (1.0–8.5)	1.9 (0.7–5.5)
CCL staff present	6.4 (2.5–16.5)	2.2 (0.8–6.1)	2.8 (0.9–8.4)
Arrival by EMS	5.4 (1.7–16.9)	3.6 (1.4–9.0)	16.9 (5.7–50.1)

CCL = cardiac catheterization laboratory; EPh = emergency pharmacist; CI = confidence interval; EMS = emergency medical services.
* One patient was transferred from the cardiac catheterization laboratory to the operating room for coronary artery bypass graft before angioplasty.

angioplasty. The role of the EPh during STEMI presentation to the ED and AMI team evaluation has not been previously described in the literature, however, it is similar to emergency resuscitation in that the pharmacist facilitates medication administration, evaluates the appropriate medication use and medication dose, supports adherence to the hospital protocols, and prevents medication-related adverse events.

We were able to show that EPh presence was independently associated with a mean 13.1-min decrease in door/diagnosis-to-CCL time and a mean 11.5-min decrease in door-to-balloon time after controlling for confounders such as CCL on-call status and means of arrival to the ED. Furthermore, the EPh was independently associated with achieving a door/diagnosis-to-CCL time of both ≤ 30 and ≤ 45 min. At our institution, arrival at the CCL to the time for balloon angioplasty averages 35 min; therefore, spending ≤ 45 min in the ED would increase the likelihood of door-to-balloon time ≤ 90 min.

To our knowledge, medication administration has not been evaluated to determine if it presents a limitation in achieving a faster door-to-balloon time. However, at our institution we felt that the decreased time intervals are likely due to the fact that EPh presence helps expedite medication administration. Specifically, the EPh can anticipate the need for AMI-related medications and can obtain them from the automated medication-dispensing cabinets and program the medication infusion pump while the nurses are starting intravenous lines, drawing blood, repeating the ECG, and placing the patient on a portable monitor. This has been the practice at our institution over the past several years, regardless of nursing staffing patterns.

Limitations

There are limitations to this study that should be recognized. Based on the retrospective design of the study it is difficult to ensure that all variables that may have affected our results were identified. Although our ED has consistent staffing patterns, evening and weekend shifts are generally considered to be more demanding for all ED staff. Because the CCL staff is on call during the evening and weekend hours, these variables are highly correlated and the inclusion of this CCL staff variable into the multivariate analysis was able to take this into consideration. Additionally, the impact of specific nursing and physician staff in the ED and for the Cardiology service were not evaluated to determine the impact on these results.

The study was designed to evaluate the presence or absence of an emergency clinical pharmacist as a member of the interdisciplinary team and what effect that has on the time outcome variables. We did not evaluate the activities of the pharmacist and how these specific activities may have contributed to the time-dependent endpoints. Our results may be due to having an extra person as part of the team during patient care and not necessarily the importance of it being a pharmacist; however, this study was not designed to determine the specific roles of each person in the interdisciplinary team and how each affected the time endpoints.

CONCLUSION

Our results indicate that the presence of a dedicated emergency clinical pharmacist during STEMI presentation to the ED is independently associated with a decrease in door/diagnosis-to-CCL and door-to-balloon time. This study supports the use of a clinical pharmacist in the ED to participate in the evaluation and treatment of STEMI patients, and suggests that pharmacists may be able to impact other time-dependent emergencies.

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ARTICLE SUMMARY

1. Why is this topic important?

Primary percutaneous coronary intervention occurring in 90 min or less of presentation to the emergency department (ED) is the key determinant of in-hospital and late mortality in patients presenting with an ST-segment elevation myocardial infarction (STEMI).

2. What does this study attempt to show?

This study suggests that the dedicated emergency clinical pharmacist (EPh) as a member of the acute myocardial infarction team can be effective in decreasing the door/diagnosis-to-cardiac catheterization laboratory (CCL) time and, ultimately, door-to-balloon time in patients presenting with an STEMI to the ED.

3. What are the key findings?

The EPh is associated with a decrease in time spent in the ED from the time of diagnosis of an STEMI (door/diagnosis-to-CCL time) and a decrease in door-to-balloon time. These results are independent of potential confounders, including the presence of on-site CCL staff, time of day and day of the week, and method of patient arrival to the ED.

4. How is patient care impacted?

Taking into consideration the concept of "time equals myocardium," EPh involvement during STEMI patient presentation and evaluation may decrease patient time in the ED from door or diagnosis to the CCL and door-to-balloon time.