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Research paper

The importance of organizational variables in treatment time for patients with ST-elevation acute myocardial infarction improve delays in STEMI

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ABSTRACT

Background: The time between arrival at the emergency department (ED) and balloon (D2B) in STEMI is one of the best indicators of the quality of care. **Our aim** is to describe treatment times and evaluate the causes of delay.
Methods: This is an observational retrospective study, including all consecutive STEMI code patients ≥18 years old treated in the ED from 2013 to 2016.All the patients were stratified into two groups: delayed group with D2B > 70 min and non-delayed ≤70. The primary variable was D2B time.
Findings: In total 327 patients were included, stratified according to their D2B as follows: 166 (67·48%) in the delayed group and 80 (32·52%) in the non-delayed group. The delayed group was older (p = 0·005), with more females (p = 0·060) and more atypical electrocardiogram (ECG) STEMI signs or symptoms (p = 0·058) (p = 0·087). Predictors of shorter D2B time were: typical STEMI ECG signs and short training sessions for nurses on identifying STEMI patients.
Interpretation: There are delays particularly in specific groups with atypical clinical presentations. Short training sessions aimed at emergency nurses correlate with shorter delay. This suggests that continuing training for emergency nurses, along with organizational strategies, can contribute to increasing the quality of care.
Clinical trial number: NCT04333381

Introduction

Ischemic heart disease is the primary cause of death in the world, accounting for up to 20% of deaths in Europe [1]. The most common clinical presentation, with the worst prognosis, is acute myocardial infarction (MI), with primary angioplasty (PPCI) being the reperfusion therapy of choice [2,3].

In 2008, with the aim of improving MI treatment, the European Stent for Life initiative was launched, which strove to facilitate the implementation of MI healthcare networks and increase the use of early PPCI as a reperfusion treatment [4].

In the country of study, programs were created under the same guidelines [5], which classifies the treatment given to each patient in a reference hospital [6] and is based on the European Society of Cardiology's (ESC) clinical guidelines for ST elevation acute coronary syndrome (STEMI). The guidelines emphasize that time

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intervals are an optimal healthcare quality indicator in STEMI treatment, being directly correlated to subsequent morbidity and mortality [7,8]. Any delay in the patient treatment system reflects the centre's response and organization capacity, as well as various sociodemographic and clinical factors [7–15].

Therefore, the establishment of systematic, organized PPCI programs has a direct impact on healthcare quality and the patients' prognosis [16].

The emergency management (ED) of the hospital is based on a continuous improvement program with respect to the quality of the healthcare processes, using the Plan-Do-Check-Act (PDCA) methodology, also known as the Deming Cycle [17]. In particular, organizational, training and management interventions have been implemented with the aim of reducing treatment delays for STEMI patients.

Our objective is to describe response times for myocardial infarctions in the case of patients who go directly to the ED of our hospital, evaluating delays between arrival time and opening the artery in correlation to sociodemographic, clinical and result factors, using the Plan-Do-Check-Act methodology to implement new continuous improvement strategies.

Methods

Study design and population

An observational retrospective study conducted in the emergency department and haemodynamic laboratory of the hospital between January 2013 and December 2016.

The study population were all adult patients with suspected STEMI activated consecutively as an MI code by the Emergency Service, who meet the following inclusion criteria: patients ≥18 years old, admitted to the ED of the hospital. Patients identified as STEMI on a pre-hospital basis were excluded as they are transferred by ambulance or helicopter directly to the Haemodynamic Unit by the emergency medical services, bypassing the ED to prevent delays. In addition, patients who did not undergo a coronary angiography and pregnant women were excluded.

Procedures

All the clinical variables were gathered retrospectively using the Data Collection Register, based on the recommendations of the clinical guidelines of the ESC [7].

The main variable of the study was the time between arrival at the ED and opening the artery (Door-to-Balloon, or D2B). An adequate D2B time was taken to be 70 min, with 10 min between arrival at the ED and conducting the ECG, and 60 min between diagnosis and the balloon procedure, in line with the clinical guidelines of the ESC [7]. As specified in the guidelines, the sample was divided into two groups: the non-delayed treatment group (D2B ≤ 70 min) and the delayed treatment group (D2B > 70 min). All the variables were compared between these two groups.

The following secondary variables were also taken into considerations:

- Intra-hospital mortality
- Hospital stay
- False positives
- Response time variables: response times included in accordance with the definition in the clinical guidelines [7]. Moreover, two groups were compared based on the adequate time interval between the first medical contact (FMC) and the ECG of 10 min, as specified in the guidelines [7]. As such, the sample was divided into the non-delayed diagnosis group (FMC-ECG ≤ 10 min) and the delayed diagnosis group (FMC-ECG > 10 min).
- Quality variables: the quality indicators for STEMI timings recommended in the current guidelines were used [7].

Organizational variables: All these variables were positively coded from the start date of the organizational measurement process.

- Creation of the MI Code Committee of the hospital: a multidisciplinary working group that regularly evaluates delays and designs improvement strategies.
- Institutional protocols: Drafting the hospital's unified and shared STEMI protocols.
- Intra-hospital transfer management: Organizational changes in the management of transfers, coordinated directly by the Emergency Department.
- Short reinforcement sessions: Short training sessions were run for emergency nurses. The education intervention takes a mixed training approach (group and individualized), that is ongoing and regular over time, with the aim of maintaining the peak effect of the professionals' knowledge. The different parts of the training program can be summarized as follows:

With respect to the group intervention, short reinforcement and update educational sessions on the MI Code were run, aimed at all emergency professionals, on a twice-yearly basis. The methodology of these sessions was based on the analysis and discussion of complex and contentious clinical case studies. At the same time, the supervising nurse or the MI code supervisor ran short 15-minute sessions twice a month on key aspects of STEMI identification, workshops and consolidation activities, for all emergency-nursing shifts. All the contents included in these sessions were the contents specified in the STEMI clinical practice guidelines of the ESC.

In terms of the individualized education intervention, within the framework of the MI Code Committee, patients whose treatment had been delayed were identified, with an evaluation of possible causes and emergency professionals who participated in the treatment of these patients. Areas for improvement were specified. The supervising nurse or the MI code supervisor then contacted the emergency nurse involved in the care of these patients. The nurse then took part in an individualized intervention based on a reflexive analysis of the case, the identification of errors and the specification of areas for improvement. In addition, they were given personalized knowledge based on their needs. The contents of the individualized education intervention were based on the recommendations of the European STEMI clinical guidelines.

All the data was collected from the information terminal of MI Code registry, a database containing all the clinical variables and response times.

Ethical approval

The study was approved by Ethics Committee of Santa Creu and Sant Pau Hospital and the reference number is IIBSP-IAM-2015-84 (version 2).

Statistical analysis

With respect to analysing the data, a descriptive analysis was conducted, giving the percentage, as well as the number of cases for the categorical variables, the mean value with the standard deviation for quantitative variables with normal distribution, and the median with the interquartile range in the case of quantitative variables with non-normal distribution. Categorical variables were compared using the Chi-squared test or Fisher's exact test, as

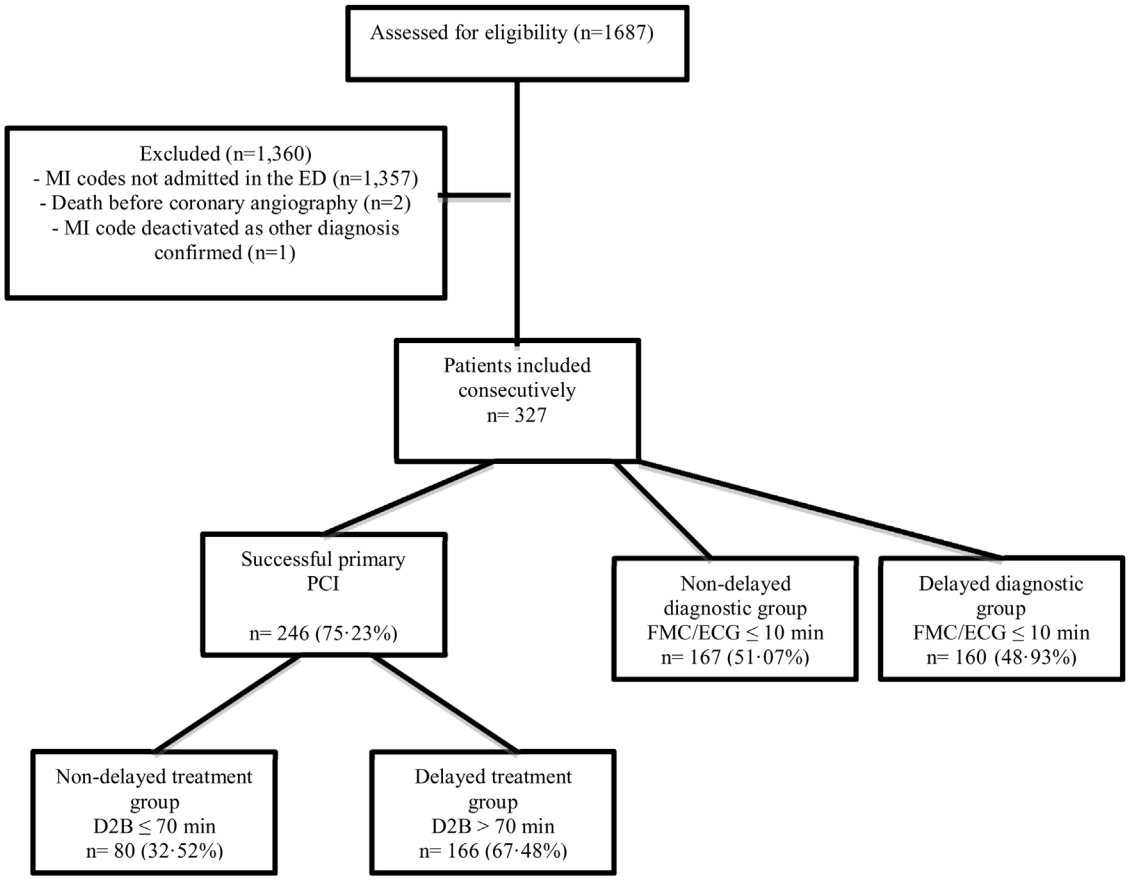

Fig. 1. Flow chart. Population included in the study.
D2B: door-to-balloon. ECG: electrocardiogram. ED: Emergency Department. FMC: first medical contact. MI: Myocardial infarction.

applicable, while the quantitative variables were compared with the ANOVA test or Mann-Whitney U test, depending on their distribution.

To evaluate the predictive factors of the time between arrival at the ED and opening the artery, a linear regression analysis was carried out, with any variables with $p < 0{\cdot}10$ in the univariate analysis being considered independent variables. Therefore, the variables taken into consideration were the patient's sex, age, working hours, chest pain in presentation, elevation of the ST segment in the ECG, and training sessions for nurses.

A 2-tailed level of significance of 5% ($\alpha = 0{\cdot}05$) was use. All analyses were conducted using the IBM–SPSS (V22·0) statistical package.

Role of the funding source

The funders of the study played no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Outcomes

Study population

The total population of patients activated as an MI code during the period of study, according to the hospital's annual report, was 1687 patients. Of these, 330 were patients activated from the ED of the hospital itself, with two patients who died at the door of the Haemodynamic Unit being excluded, as well as one who was deactivated after another diagnosis was confirmed. This resulted in a final sample of 327 patients. 12·8% (n = 42) of the acute MI codes activated were false positives, while 75·23% (n = 246) were given primary PCI treatment. Of those, 32·52% (n = 80) were assigned to the non-delayed treatment group (D2B ≤ 70 min) and 67·48% (n = 166) to the delayed treatment group (D2B > 70 min). Moreover, two groups were distributed based on whether or not there was a delay in diagnosis, with 51·07% (n = 167) being assigned to non-delayed diagnosis group (FMC/ECG ≤ 10 min) and 48·93% (n = 160) to the delayed diagnosis group (FMC/ECG > 10 min) (Fig. 1).

In terms of the clinical profile, when comparing the delayed treatment groups, it was observed that patients who presented with the longest delays were elderly ($p = 0{\cdot}005$), female ($p = 0{\cdot}060$), with atypical symptomatology and electrocardiogram ($p = 0{\cdot}087$ and $p = 0{\cdot}058$, respectively), and usually presented outside working hours ($p = 0{\cdot}001$). Moreover, the patients in the delayed treatment group had a longer hospital stay (5 (3–8) day vs. 4 (3–6) days; $p = 0{\cdot}041$) (Table 1).

Meanwhile, when patients were compared according the delay in diagnosis, it was observed that there was a longer delay in the case of patients who had had other medical contact before going to the Emergency Department ($p = 0{\cdot}004$) and in more severe cases (AMI Killip III/IV) ($p = 0{\cdot}006$). With respect to symptomatology, there was a longer delay in performing the ECG in the case of patients who did not present chest pain ($p = 0{\cdot}004$), who were not sweating ($p = 0{\cdot}025$) and whose first event was a syncope ($p = 0{\cdot}026$) or cardiorespiratory arrest (0·001). A higher mortality rate was also observed in the cases with a delay in the diagnosis ($p = 0{\cdot}039$) (Table 1).

Table 1
Baseline clinical characteristics of study participants, organizational variables and quality indicators of STEMI. The figures show n (%). Mean ± standard deviation. CRA: cardiorespiratory arrest. DLP: dyslipidemia. DM: Diabetes mellitus. ECG: electrocardiogram. ED: Emergency Department. FMC: first medical contact. GPC: General poor condition. HTA: arterial hypertension. MH: medical history. PCI: percutaneous coronary intervention.

Variables	STEMI Code n (%)	ED/Balloon ≤ 70 min	ED/Balloon >70 min	p	FMC/ECG ≤ 10 min	FMC/ECG >10 min	p
Number of patients	327(100)	80(32·5)	166(67·5)		167(51·1)	160(48·9)	
Females	78(23·9)	12(15)	43(25·6)	0·06	36(21·6)	42(26·2)	0·320
Age (mean ± SD)	64 ± 14	61 ± 12	66 ± 14	0·005	64 ± 13	64 ± 15	0·711
HTA	198(60·6)	45(56·3)	104(61·9)	0·395	106(63·5)	92(57·5)	0·269
DLP	177(54·1)	40(50)	101(60·1)	0·133	92(55·1)	85(53·1)	0·722
DM	84(25·7)	19(23·8)	47(28)	0·481	42(25·1)	42(26·3)	0·82
Tobacco use	196(59·9)	56(70)	100(59·5)	0·239	100(59·9)	96(60)	0·618
Obesity	63(19·3)	21(26·3)	32(19·2)	0·204	31(18·6)	32(20·1)	0·721
Cardiological MH	80(24·5)	17(21·3)	37(22)	0·89	44(26·3)	36(22·5)	0·419
Killip III/IV	58(19·9)	13(16·5)	32(20·6)	0·442	21(13·5)	36(26·5)	0·006
FMC ED	184(56·3)	44(55)	103(61·3)	0·344	107(64·1)	77(48·1)	0·004
Working hours	120(36·7)	41(51·3)	48(28·6)	0·001	59(35·3)	61(38·1)	0·60
PCI	249(75·9)	80(100)	166(100)	0·139	126(75·4)	118(73·8)	0·724
Anterior ECG	132(40·4)	36(45)	69(41·3)	0·162	68(40·7)	64(40·3)	0·397
Inferior ECG	133(40·7)	38(47·5)	70(41·9)		65(38·9)	67(42·2)	
Lateral ECG	22(6·7)	5(6·3)	15(9)		15(9)	7(4·4)	
Chest pain	254(77·4)	70(87·5)	131(78·4)	0·087	141(84·4)	113(71·1)	0·004
Atypical pain	72(22·02)	10 (12·5)	36 (21·6)	0·087	26 (15·6)	46 (28·9)	0·004
Dyspnea	71(21·8)	13(16·5)	37(22·2)	0·3	34(20·5)	37(23·3)	0·543
Syncope	19(5·8)	3(3·8)	9(5·4)	0·588	5(3)	14(8·8)	0·026
Sweating	140(42·9)	38(48·1)	73(43·7)	0·518	81(48·8)	58(36·5)	0·025
Nausea/vomiting	96(29·4)	19(24·1)	58(34·7)	0·092	53(31·9)	42(26·4)	0·275
GPC/Weakness	46(14·1)	8(10·1)	21(12·6)	0·578	25(15·1)	20(12·6)	0·517
CRA	36(11)	7(8·9)	20(12)	0·465	9(5·4)	27(17)	0·001
ECG ST elevation	267(81·7)	71(89·9)	134(80·2)	0·058	135(81·3)	130(81·8)	0·919
In-hospital Mortality	38(11·6)	9 (11·3)	21 (12·5)	0·778	13(7·8)	24(15)	0·039
Hospital stay	5(3–8)	4(3–6)	5(3–8)	0·041	5(3–7)	5(3–9)	0·227
STEMI Code Committee	173(52·9)	47(58·8)	90(53·9)	0·472	88(52·7)	85(53·5)	0·89
Institutional protocols	173 (52·9)	47(58·8)	90(59·3)	0·472	88(52·7)	85(53·5)	0·89
Intra-hospital transfer management	173(52·7)	47(58·8)	90(53·6)	0·443	88(52·7)	85(53·1)	0·938
Short sessions for nurses	49(14·9)	13(16·3)	27(16·1)	0·971	21(12·6)	28(17·5)	0·212
Pain/Balloon <12 h	217(87·5)	75(93·8)	142(84·5)	0·04	117(92·1)	100(82·6)	0·024
Pain/FMC if PCI 12 h	234(94·4)	76(95)	157(94)	0·753	122(95·3)	112(93·3)	0·50
ECG/Balloon<60min	47(18·9)	36(45)	10(63)	<0,001	29(22·7)	18(15)	0·188
ED/ECG < 10 min	222(67·9)	71(88·8)	95(56·5)	<0,001	166(99·4)	56(35)	<0,001
FCM/ECG<10min	167(51·1)	52(65)	75(44·6)	0·003	167 (100)	0(0)	0·001

Response times

The median time between arrival at the ED and opening the artery (ED/balloon) was 88 min (65–121). In addition, in the delayed treatment group, a greater delay was observed in all the AMI response times (Table 2).

Moreover, the median time between the first medical contact and the electrocardiogram (FMC/ECG) was 10 min (5–26) and the patients whose diagnosis was delayed (FMC/ECG > 10 min) also had a greater delay in all the intervals except Activation–Haemodynamics and Haemodynamics–Balloon (Table 2).

There was less adherence to the quality indicators among the delayed treatment group and the delayed diagnosis group (Table 1).

Treatment delay predictive factors

The independent predictive factors of the time between arrival at the ED and opening the artery (D2B) were the presence of elevation of the ST segment in the electrocardiogram ($p < 0{\cdot}001$) and short reinforcement training sessions being run for emergency nurses ($p = 0{\cdot}028$) (Table 3).

Discussion

The following aspects have been determined in our observations: 1) The STEMI patients with the longest delays are mostly women and the elderly. 2) These patients with the longest delay also present higher mortality and longer hospital stays. 3) The pain/FMC, D2B and ECG/Balloon time intervals and the total ischemia time are higher than the recommendations in the guidelines. 4) Short training sessions for emergency nurses can lead to a reduction in the time between arrival at the ED and balloon.

The results confirm the evidence consulted on delays with respect to sociodemographic and clinical data. As various authors have found, our observations show that the D2B time and the MI activation code is higher in the case of women [18,19]. As other authors have suggested, one of the possible causes is that women present more atypical symptoms, resulting in a delay in diagnosis [7,20].

The results show that atypical clinical presentation and electrocardiogram are causes of delay in the case of elderly patients, as observed in different studies consulted in the literature [21,22]. The results are also in line with previous observations, such as the fact that patients who suffer a longer delay present outside working hours, are more serious and have had medical contact prior to coming to the ED [14,23].

With respect to the clinical variables in the results, our study confirms that delays in the diagnosis have an impact on mortality [21,24]. Intra-hospital cardiac mortality is higher than in other studies in a stage in which AMI treatment was already organized by MI code networks [25]. However, it should be noted that 11·4% of the population included in the study were patients whose first event was cardiorespiratory arrest, and there is evidence of high mortality among this group of patients [23].

Table 2
Main variable and response times in acute myocardial infarction. The figures show n (%) Median (interquartile range). Time intervals: minutes (min). ECG: electrocardiogram. ED: Emergency Department. FMC: first medical contact. Hemo: haemodynamic.

Time Variables	Total STEMI CODE	ER/Balloon ≤70 min	ER/Balloon >70 min	p	FMC/ECG ≤ 10 min	FMC/ECG > 10 min	p
Number of patients	327 (100)	80(24·46)	166(50·76)		167(51·07)	160(48·93)	
Pain/ FMC	80(25–180)	60(25–120)	101(30–244)	0·019	65(25–141)	102(24–265)	0·032
FMC/ ECG	10(5–26)	6(4–17)	12(7–31)	<0·001	5(4–8)	27(15–59)	0·001
ECG/ Activation	30(12–75)	12(5–33)	35(15–99)	<0·001	25(10–56)	33(15–95)	0·007
ED/Balloon	88(65–121)	55(47–64)	108(86–161)	<0·001	78(59–110)	97(75–158)	<0·001
Activation/Hemo	30(20–35)	21(14–31)	30(25–37)	<0·001	30(17–36)	30(20–35)	0·752
Hemo/Balloon	25(20–31)	22(18–25)	27(22–35)	<0·001	25(20–29)	26(20–33)	0·191
FMC/Balloon	109(77–160)	67(55–100)	129(95–195)	<0·001	90(65–125)	131(97–215)	<0·001
Pain/Balloon	207(135–400)	142(95–203)	256(171–495)	<0·001	185(118–265)	265(155–536)	<0·001
ECG/Balloon	88(65–132)	61 (49–84)	100 (77–164)	<0·001	87 (66–156)	90 (61–120)	0·059

Table 3
Predictive factors of delay in D2B for STEMI patients. CI: confidence interval. ECG: electrocardiogram.

Variables	HR	95% CI	p-value
Gender	0.061	(−24.208 to 69.426)	0.342
Age	0.083	(−0.483 to 2.363)	0.194
Working hours	−0.102	(−71.693 to 6.082)	0.098
Chest pain	−0.069	(−76.686 to 21.352)	0.267
ECG with ST elevation	−0.258	(−157.037 to −57.103)	<0.001
Nurse training sessions	−0.135	(−107.141 to −6.263)	0.028

The results obtained with respect to increased hospital stay in the delayed group, as well as in terms of false positives, are in concordance with the studies in the literature [26].

As seen in other reported series, when analysing the times obtained, significant delays and low adherence to the STEMI quality indicators were observed [7,14,24]. These records focus on the D2B time because it is considered to be an optimal indicator of the hospital's healthcare quality and the degree of alignment with the PPCI program [11]. In contrast to other studies, the non-delayed treatment group was defined with a D2B ≤ 70 min [21,23,24]. Moreover, in our study, the time between arrival at the ED and electrocardiogram is adequate, particularly when the patient has not had any medical contact before coming to the ED, and differs from other studies insofar as the haemodynamic-balloon interval is not subject to delays attributable to technical difficulties in the PCI [28].

It should be highlighted that, in the case of the pain/FMC interval and even the pain/balloon intervals, the delay is more dependent on the patient themselves. Therefore, education and awareness campaigns should be run among the population [27]. The rest of the intervals recorded correspond to system delays. It is in relation to these intervals that a clear Plan-Do-Check-Act strategy must be established, with measures adapted to resolve them.

The findings of our research confirm that short reinforcement training sessions on MI for emergency nurses lead to an improvement in delays in the D2B, generating improved diagnosis and treatment [21]. Despite evidence on the efficacy of organizational variables with respect to reducing MI response times, few authors include these variables in their evaluation of delays [29,30]. It should be noted that the studies that do incorporate these variables in their records analyse the delays in a fragmented way, without establishing an overall continuous improvement methodology for healthcare quality. In contrast, our study is focused towards this purpose. The research results confirm that implementing different organizational strategies aligned with the Plan-Do-Check-Act model leads to a reduction in delays in the system. Running short training sessions on AMI for emergency nurses appears to contribute towards improving delays in D2B.

The main limitations of this study are the sample size, which is retrospective and taken from a single hospital. The fact that the data is taken from the *Codi IAM* register increase the reliability of the results, as it can be audited and is consistent with other data reported.

In conclusion, response times in cases of myocardial infarction are subject to delays, particularly in specific groups of patients that require special supervision. The measures incorporated using the Plan-Do-Check-Act methodology provide specific interventions throughout the process that guarantee continuous improvement, increasing the safety and quality of the process. Moreover, regular audits should be conducted to quantify and compare healthcare quality, delays and clinical results, in order to improve these parameters. Hospitals and healthcare networks should allocate time and resources to measuring their results and developing continuous improvement strategies to achieve optimal performance.

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Role of the funding source

The funders of the study played no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declaration of conflicts of interest

The authors have no conflicts of interest to declare.

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What is Known/ What this paper adds?

Evidence before this study
According to the current STEMI guidelines of the ESC, the recommended door-to-balloon time should be lower than 60 min, with the time between the first medical contact and the electrocardiogram lower than 10 minutes, in the case of patients who go directly to the Emergency Department of a hospital with primary PCI capacity. Various records show the influence of sociodemographic, clinical and result factors on increasing delays in treating MI patients. However, there are hardly any studies that correlate delays with specific organizational variables.

Added value of this study
This study defines the delay group in accordance with the current STEMI clinical guidelines of the ESC, including clinical variables that increase delay times and incorporating specific organizational variables based on the Plan-Do-Study-Act methodology that may be extrapolated to other institutions. The short training sessions aimed at emergency nurses proved to be a predictive factor with respect to delays in the D2B time.

Implications of all the available evidence
This study shows the importance of incorporating organizational and training measures for emergency nurses to reduce MI treatment times for patients who come into the ED. The study also highlights the use of regular audits as a quality control measure of the healthcare provided.

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