ORIGINAL ARTICLE

Barriers and Procedures to Reduce Treatment Delay in ST-Segment Elevation Acute Coronary Syndrome with Primary Percutaneous Coronary Intervention. 20-Year Experience of a Tertiary Care Center in a Densely Populated City

Detección de barreras e implementación de procedimientos para reducir la demora en el tratamiento del síndrome coronario agudo con elevación del segmento ST mediante angioplastia primaria. Experiencia de 20 años de un centro de referencia en una ciudad de alta densidad demográfica

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ABSTRACT

Background: The delay to reperfusion of ST-segment elevation acute coronary syndrome (STEACS) is a key factor in its prognosis, and its reduction could reduce morbidity and mortality.
Objective: The aim of this study was to identify and modify the barriers detected in 20 years of STEACS treatment in a tertiary care center of a densely populated city to evaluate their effect on the outcome of the procedure.
Methods: A total of 3007 patients with STEACS within 12 hours of symptoms onset were prospectively and consecutively included to undergo primary percutaneous coronary intervention (PCI) from January 1, 2000 to December 31, 2019. Time from symptoms onset to balloon inflation was divided into intervals. After barriers were identified (2000-2009), the procedure was changed. The population was divided into two groups (G) G1: pre-implementation (2000-2009) and G2: post-implementation (2010-2019) of changes.
Results: G1 included 1409 and G2 1598 patients with no demographic differences except for the type of PCI. Delays were identified in diagnosis, communication between physicians, transfer and admission of the patient to the hemodynamics lab. Procedural changes decreased first medical contact-hemodynamic team contact interval [G1: 90 min (36-168) vs. G2: 77 min (36-144) p <0.01] and hemodynamic team contact-hemodynamics lab admission interval [G1: 75 min (55-100) vs. G2: 51 min (34-70) p <0.01] and reduced in-hospital (G1: 9,2% vs. G2: 6,7% p <0,01) and 6-month (G1: 13.1% vs. G2: 7.5% p <0. 01) mortality.
Conclusions: Delay in diagnosis, difficulty in communication and type of transfer were the most important causes of delay. Implementing a procedural protocol reduced delays. Continuous evaluation of results and permanent education constitute the fundamental cornerstones for optimizing network care programs.

Key words: Acute Coronary Syndrome - ST Elevation Myocardial Infarction - Time Factor - Time-to-Treatment - Angioplasty

RESUMEN

Introducción: La demora a la reperfusión del síndrome coronario agudo con elevación del segmento ST es un factor determinante en el pronóstico. Su reducción podría disminuir la morbimortalidad.
Objetivo: Identificar y modificar las barreras detectadas en 20 años de tratamiento del síndrome coronario agudo con elevación del segmento ST en un centro de tercer nivel de una ciudad de alta densidad demográfica para evaluar su efecto en el resultado del procedimiento.
Material y métodos: Incluimos prospectiva y consecutivamente del 01/01/2000 al 31/12/2019, 3007 pacientes con síndrome coronario agudo con elevación del segmento ST dentro de las 12 h de iniciados los síntomas para realizar angioplastia primaria. Se dividió el tiempo desde el comienzo de los síntomas hasta la insuflación del balón en intervalos.
Luego de identificar las barreras (2000-2009) se incorporaron cambios al procedimiento. Se organizó a la población en 2 grupos (G) G1: preimplementación de cambios (2000-2009) y G2: posimplementación (2010- 2019).
Resultados: Se incluyeron en G1 1409 pacientes y en G2 1598. Sin diferencias demográficas, excepto por el tipo de angioplastia. Se identificaron demoras al realizar el diagnóstico, de comunicación entre médicos, del traslado y del ingreso del paciente a hemodinamia. Con los cambios, disminuimos el intervalo consulta-contacto con el hemodinamista [G1: 90 min (36-168) vs. G2: 77 min (36-144) p <0,01] y el intervalo contacto hemodinamista-ingreso a Hemodinamia [G1: 75 min (55-100) vs. G2: 51 min (34-70) p <0,01]. Se redujo la mortalidad intrahospitalaria (G1: 9,2% vs. G2:6,7% p <0,01) y al 6to mes (G1: 13,1% vs. G2: 7,5% p <0,01).

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Conclusiones: El retraso al diagnóstico, la dificultad en la comunicación y la forma de traslado fueron las principales causas de demora. La implementación de un protocolo de procedimientos permitió reducir las demoras. La evaluación continua de resultados y la educación permanente, constituyen los pilares fundamentales para la optimización de programas de atención en red.

Palabras Clave: Síndrome coronario agudo - Infarto del miocardio con elevación del segmento ST - Factores de tiempo - Tiempo para el tratamiento - Angioplastia

Abbreviations

PCI	Percutaneous coronary intervention	**EHT**	Emergency hemodynamics team
ST	Standard deviation	**IQR**	Interquartile range
DBT	Door-to-balloon time	**STEACS**	ST-segment elevation acute coronary syndrome

INTRODUCTION

The treatment of choice in ST-segment elevation acute coronary syndrome (STEACS) is reperfusion, preferably with primary percutaneous coronary intervention (PCI) or thrombolytics in patients who do not have access to PCI. (1, 2) Currently, between 15% and 30% of patients with reperfusion criteria do not receive adequate treatment, and more distressing, less than 45% of patients reach reperfusion within the recommended times due to lack of access to an adequately organized health system. (3-6) It should be noted that access to treatment is among the multiple factors that determine mortality at the time of ischemia, due to the important effect in the affected tissue viability. It is therefore essential to reduce it with protocolized procedures analyzing and correcting factors leading to these delays. It has been shown that connectivity between different complexity hospitals should be improved through the interaction with an efficient medical emergency service that allows increasing not only the proportion of patients reperfused but also the reduction of delays, in order to recover left ventricular function and hence decrease morbidity and mortality. (7, 8)

The aims of this work were firstly, the presentation of results of a 20-year experience in the treatment of STEACS in the City of Buenos Aires, divided into two stages: a first stage of identification of barriers and delays to reperfusion and a second stage after the introduction of certain modifications to overcome these barriers; and secondly, through the analysis of these data, to develop new protocols to improve STEACS treatment in our setting.

METHODS

A population of 3007 patients with STEACS activating the hemodynamics lab for primary or rescue PCI within 12 hours of symptom onset at Hospital Gral. de Agudos Dr. Cosme Argerich or referred by the Autonomous City of Buenos Aires (CABA) and Greater Buenos Aires public or private hospitals, were prospectively and consecutively included in the study between January 1, 2000 to December 31, 2019. Primary PCI was the procedure performed without previous thrombolytic administration and rescue PCI was the one carried out with the same admission criteria, but with prior thrombolytic administration (100% streptokinase) without reperfusion criteria. Data collected by the emergency hemodynamics team (EHT) were prospectively recorded through a specially designed questionnaire, and incorporated and analyzed in a database. A series of modifications were implemented to improve times to PCI, after analyzing the data in 2009 (5, 6) (Table 1). A multidisciplinary team, involving different areas responsible for STEACS patient care, including admission administrative staff, external shift emergency department physicians and nurses, stretcher bearers and auxiliaries in charge of patient transfer, cardiology residents and EHT physicians, nurses and technicians was formed at our hospital to optimize time to diagnosis, patient admission to the hemodynamics lab and primary PCI procedure, with the consequent periodic feedback of results. In the case of patients referred from other centers, communication with centers without an on-call cardiologist was improved, to aid STEACS diagnosis through electrocardiograms sent via smartphones, and hence shorten times to reperfusion. (9) In turn, the request for PCI was centralized by coordination with the public emergency medical care system of the Buenos Aires City Government (SAME), which started to prioritize these transfers, and in patients who were hemodynamically stable (the majority), transfer was initiated by the physician who requested it with the ambulance of the referral center (until 2009 patients were transferred with the mobile coronary care unit of the tertiary care hospital (Table 1). These changes were accompanied with the presentation of norms to optimize STEACS treatment to the authorities of Buenos Aires City. The population was divided into two periods; group 1 (G1) (before implementation of modifications) from January 1 to December 31, 2009, and group 2 (G2) (post-implementation) from January 1, 2010 to December 31, 2019. Admittedly, the implementation of modifications took some time, due, in many cases, to participant resistance as a result of unawareness of responsibilities and ignorance of the importance of time in STEACS treatment.

Variables

In addition to demographic, address and type of medical coverage data, baseline clinical, angiographic, infarct presentation and means of patient arrival to the health care system (own means, SAME or private ambulance) characteristics and in-hospital and 6-month outcomes were prospectively evaluated.

A series of intervals were defined for time analysis (Figure 1).

Interval A (IA): Time from symptom onset to arrival to emergency department of the hospital activating the system.

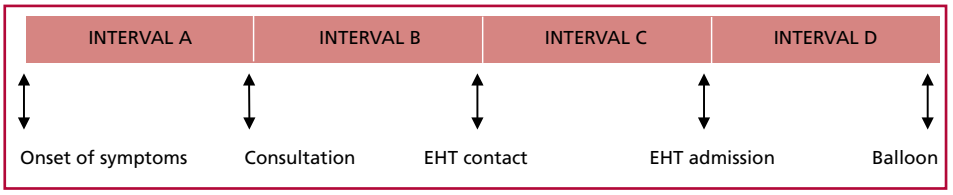
Interval B (IB): Time between hospital arrival to telephone contact with the EHT.

Table 1. Barriers that prolong time to reperfusion (2000-2009) and strategies implemented to correct them (2010-2019)

Barriers prolonging time to reperfusion (2000-2009) (5, 6)	Strategies implemented (2010- 2019)
Delay in ECG performance and interpretation	Emergency room priority of care for patients with chest pain.
Difficulty to communicate with the on-call hemodynamics specialist	ECG via WhatsApp in case of diagnostic uncertainty (9) Centralized communication between physicians through the SAME coordinator line
Patient transfer with ambulance from the receiving tertiary care center	Patient transfer with ambulance from the referral center
Delays in hemodynamics lab admission	Skip passage through the emergency room
Delays in patient and hemodynamics lab preparation	Patient and hemodynamics lab preparation by the cardiology resident in charge of procedures outside working hours.

ECG: Electrocardiograma. SAME: Emergency Medical Care System of the Buenos Aires City Government

Fig. 1. Time intervals analyzed



Interval A: From onset of symptoms to patient arrival to the emergency department of the hospital activating the system. *Interval B*: From hospital arrival to contact with the emergency hemodynamics team (EHT). *Interval C*: From EHT contact to patient admission to the hemodynamics lab. *Interval D*: From patient admission to the hemodynamics lab to first balloon inflation

Interval C (IC): Time between EHT contact to patient admission to the hemodynamics lab.

Interval D (ID): Time between patient admission to the hemodynamics lab to first balloon inflation. To homogenize criteria, this time interval in patients referred from another center constitutes the door-to-balloon time (DBT).

A form was designed where each intervening area recorded times. The different times were taken as follows:

- Time of symptom onset and time of direct patient arrival or with relatives.
- Call time is the moment of telephone contact between the physician requesting the procedure and the EHT.
- Time of patient admission to the hemodynamics lab refers to the first contact between any EHT member and the patient.
- Time of first balloon inflation in the culprit artery is recorded by the hemodynamics technician using the time in the angiography system.

Statistical analysis

Categorical variables are expressed as frequency and percentage and continuous variables as mean ± standard deviation (SD) or median and interquartile range (IQR) according to their distribution. The analysis of categorical variables was made using the chi-square test or Fisher's exact test, as applicable, and continuous variables were analyzed with the two-tailed Student's t test or the Mann-Whitney test according to their distribution. STATA 13.0 software was used and $p < 0.05$ was considered statistically significant in all cases.

Ethical considerations

The Ethics Committee waived the need for patient authorization since no personal data were used.

RESULTS

A total of 3007 patients with mean age 59±12 years and 83% men, were included in the study. Population characteristics described in Table 2 show that significant differences between groups were only found in the type of PCI.

Patients presented a high prevalence of hypertension (57%), sedentarism (72%), smoking habit (61%) and diabetes (17%). Around 17% of patients had history of myocardial infarction and 6% of heart failure.

Acute myocardial infarction was anterior in 47% of cases and inferior in another 47%. On admission, almost 80% of patients presented Killip and Kimball A, while the prevalence of cardiogenic shock was 11%. The STEACS culprit artery was the left anterior descending artery in 46% of cases, the right coronary artery in 36% and the circumflex artery in 14%. Almost 80% of patients presented TIMI 0 flow in the culprit artery and procedural success was above 90%. Fifty-six percent of the population had medical coverage and 64% lived in the City of Buenos Aires. No significant differences were found between groups for these parameters (Table 2). Overall population delay from symptom onset to admission was 75 min (IQR 25-75: 30-180 min) with no significant differences between groups. The changes introduced significantly decrease IB [G1: 90 min (36-168) vs, G2: 77 min (36-144), $p < 0.001$] and IC, both in the total population [G1: 65 min (45- 115) vs. G2: 50 min (28-100) $p < 0.01$], patients referred from other hospitals [G1: 75 min (55-100) vs. G2: 51min (34-70) p

Table 1. Basal characteristics of global, Group1 and Group 2 patients

	Global (n=3007)	Group 1 (n=1409)	Group 2 (n=1598)	p
Male sex n (%)	2496 (83)	1155 (82)	1329 (83)	NS
Age (years)	59 ± 12	59 ± 12	60 ± 11	NS
Hypertension n (%)	1701(57)	774 (55)	927 (58)	NS
Dyslipidemia n (%)	1226 (41)	602 (43)	624 (39)	NS
Smoking n (%)	1832 (61)	873 (62)	959 (60)	NS
Diabetes n (%)	519 (17)	241 (17)	278 (17)	NS
Family history n (%)	580 (19)	282 (29)	298 (19)	NS
Sedentarism n (%)	2178 (72)	1029 (73)	1149 (72)	NS
History of myocardial infarction n (%)	511 (17)	254 (18)	257 (16)	NS
Prior coronary artery bypass grafting n (%)	18 (0.6)	7 (0.5)	11 (0.7)	NS
History of peripheral artery disease n (%)	136 (5)	56 (4)	80 (5)	NS
History of stroke n (%)	50 (1.6)	22 (1.5)	28 (1.7)	NS
History of heart failure n (%)	182 (6)	82 (6)	100 (6)	NS
Primary PCI n (%)	2743 (91)	1235 (87)	1508 (94)	<0.01
Rescue PCI n (%)	264 (9)	174 (13)	100 (6)	<0.01
Killip and Kimball A n (%)	2360 (78)	1103 (78)	1257 (79)	NS
Killip and Kimball D n (%)	324 (11)	158 (11)	166 (10)	NS
Anterior infarct n (%)	1411 (47)	655 (46)	756 (47)	NS
Patients living in CABA n (%)	1944 (65)	897 (64)	1047 (65)	NS
Patients of Greater Buenos Aires n (%)	1063 (35)	512 (36)	551 (35)	NS
Patients with medical coverage n (%)	1308 (43)	593 (42)	715 (45)	NS
Patients without medical coverage n (%)	1699 (57)	816 (58)	883 (55)	NS
Hospital admission by patient own means n (%)	1765 (59)	835 (59)	930 (58)	NS
Hospital admission by ambulance n (%)	1242 (41)	574 (41)	668 (42)	NS
Consultation to hospitals with hemodynamics capability n (%)	1462 (49)	674 (47)	788 (49)	NS
Referred from another hospital n (%)	1545 (51)	735 (53)	810 (51)	NS
Baseline TIMI flow 0 in IRA n (%)	2368 (79)	1106 (79)	1262 (79)	NS
1-vessel disease n (%)	1578 (52)	748 (53)	830 (52)	NS
2-vessel disease n (%)	808 (27)	383 (27)	425 (27)	NS
3-vessel disease n (%)	487 (16)	220 (16)	267 (17)	NS
Left main coronary artery disease	134 (4)	58 (4)	76 (5)	NS

PCI: Percutaneous coronary intervention. CABA: Autonomous City of Buenos Aires. IRA: Infarct-related artery

<0.01], and those who consulted at our center [G1: 43 min (23-59) vs. G2: 28 min (20-60) p <0.01] (Figure 2).

Door-to-balloon time in patients with primary PCI who were referred from another center was 35 min (23-55) in G1 and 28 min (22-58) in G2. In G2, more than 90% of patients had DBT below 90 min in referred patients and 55% in patients consulting at our center. In the latter group, ID was 33 min (27-57), so most of the delay was found in the diagnosis and communication with the EHT (Figure 2). The consultation-reperfusion goal (IB + IC + ID) <120 min for referral patients was attained by 8.9% of cases in G1 and 21.1% in G2 (p <0.01). Also, the door-to door goal (IB +IC) <30 min was significantly improved (G1: 13.7% vs. G2: 25.4%; p <0.01). Patient survival significantly improved both in the hospital setting (G1: 90.8% vs. G2: 93.3%; p ≤0.01) as in the 6-month follow-up period (G1: 86.9% vs. G2: 92.5%; p <0.01) (Figure 3).

DISCUSSION

STEACS is one of the most challenging pathologies for the health system. Early diagnosis allows the adoption of strategies to reperfuse the myocardium. Same as in the rest of our country, primary PCI is the reperfusion strategy of choice in the city where we work, and over the years, it has gained ground in detriment of fibrinolytics. (4) We have also observed a decrease of in-hospital mortality, that although is still above some

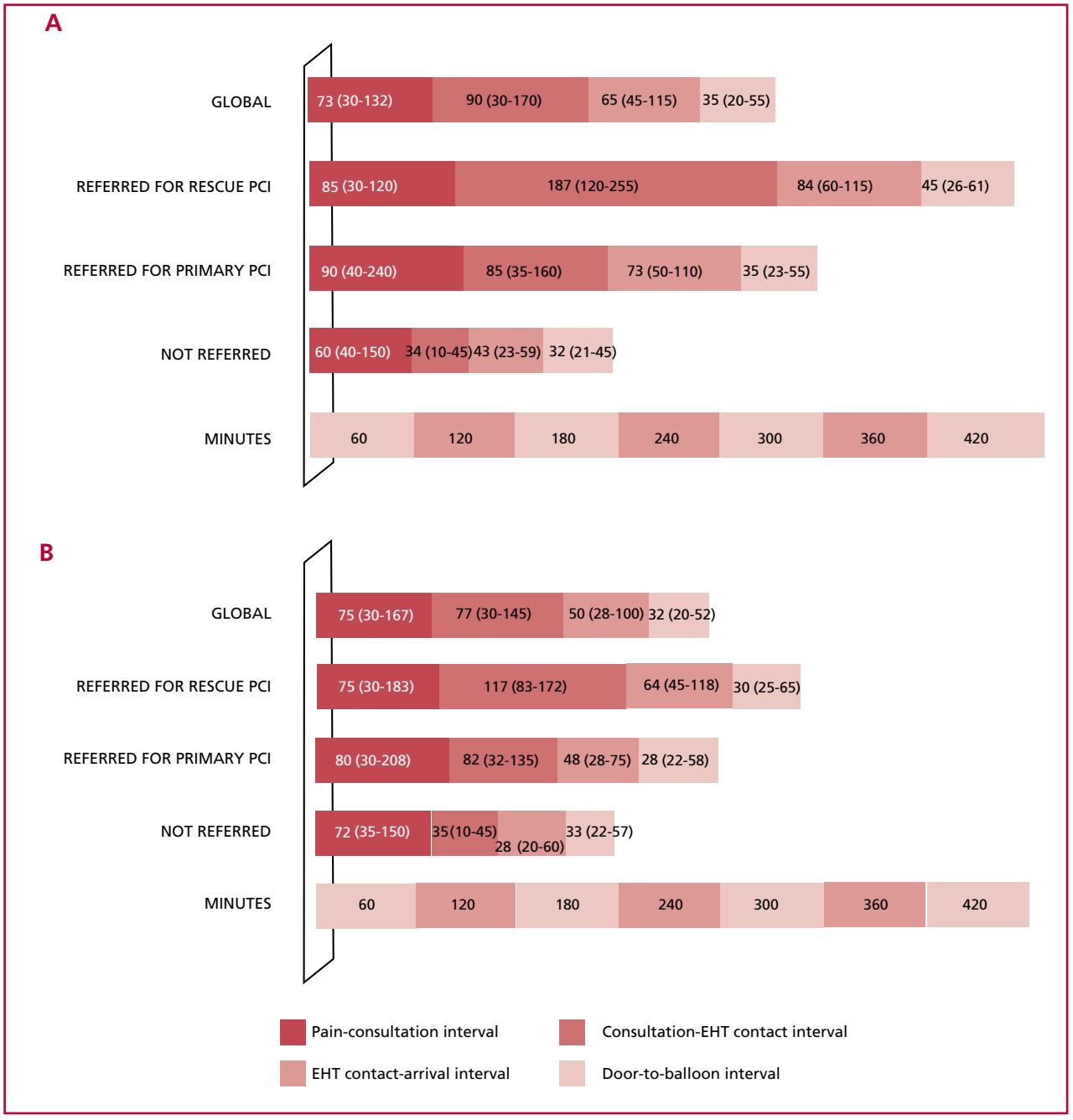


Fig. 2. Time intervals analyzed in group 1 (A) and group 2 (B), with the different subpopulations of patients forming each group

international registries, is lower than other registries published in our setting. (3, 10-13) This decrease is possibly due to the development of new drugs, greater experience of the treating medical team, better equipment, and improved times to primary PCI, translating into a better quality of care.

Knowledge of general and local barriers in times to treatment allows the implementation of corrective measures and the evaluation of their impact over time. The modifications applied reduced DBT both in patients transferred from other centers to our hospital as in those who consulted spontaneously, with shorter DBT than those reported by other registries of our setting, (12, 14) Regarding this last point, it is necessary to clarify that registries always report a longer DBT in patients who consult a center with hemodynamics capability directly than in those transferred from another center, because the pre-activation of the hemodynamics lab reduces DBT in this last group of patients. (12, 15) Therefore, we consider that registries should divide these populations, or if both populations are taken globally, DBT in a center will depend on the prevalence of patients transferred from other facilities, as it will be longer in centers with lower

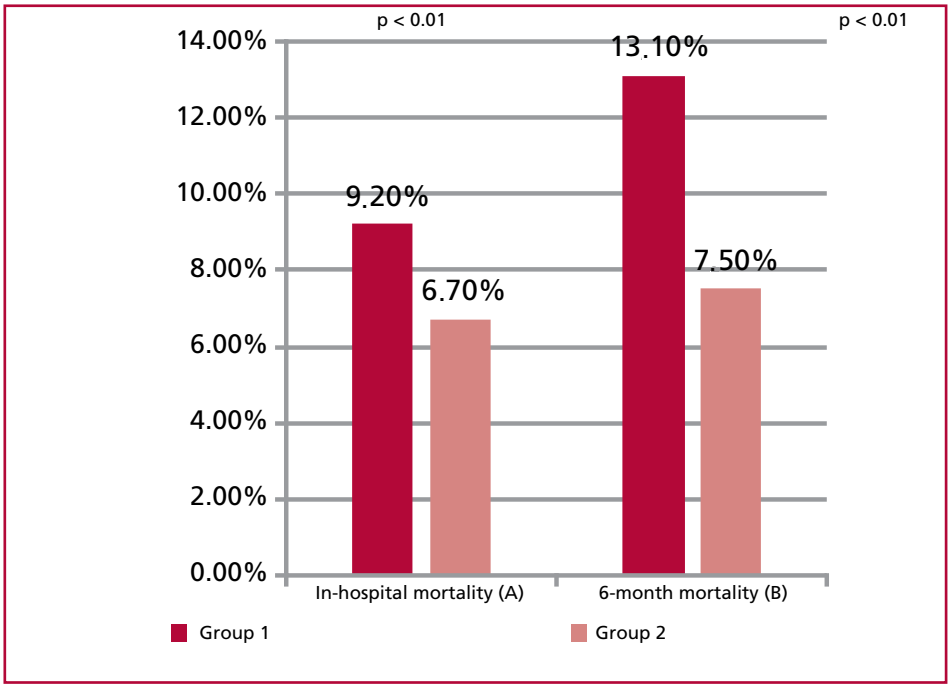


Fig. 3. In-hospital and 6-month mortality in Group 1 and Group 2

percentage of this type of patients. (12) It is also important to establish how is DBT defined in the different studies, since there are publications (16) that start measuring it from patient admission to the first hospital (referral hospital) and this could lead to erroneous comparisons. (14) In our experience there was a reduction in times to PCI after modifications in the system, similar to other registries in our setting. (13, 15) Since SAME ambulances do not have the capacity to perform an electrocardiogram at home, they transfer the patient to a hospital without hemodynamics capability, losing time to diagnosis and EHT pre-activation. We have made suggestions to the authorities to improve this point. Usually, a diagnostic electrocardiogram is taken more rapidly in patients who arrive at the hospital by ambulance, so it would be useful to raise awareness in the population to call the emergency number (107 in the City of Buenos Aires) when a person has chest pain, instead of going directly to the hospital. (1, 17-19) Also, those responsible of receiving patients in the hospital emergency room should be aware that patients consulting for chest pain must have priority of care with an electrocardiogram performed within 10 minutes of consultation. (20-22) In turn, the electrocardiogram must be evaluated as soon as possible by the on-call cardiologist, or in case the institution does not have one, send it remotely (via smartphone) to a doctor that can diagnose STEACS. (9, 23, 24) For patients presenting at a center without primary PCI capability, the time elapsed between patient arrival to the hospital to his/her transfer by ambulance to a center with primary PCI capability, is a measure of quality of care, and a duration ≤30 min is recommended to accelerate reperfusion treatment. (1, 21, 25) With respect to this point, the implementation of a hemodynamically stable patient transfer by ambulance from the referral hospital, without need for a mobile coronary care ambulance, has shortened door-to-door time. This fast transfer is safe and beneficial in this group of patients, as shown by different registries. (26, 27) Although this time interval has improved after the modifications, there are still shortcomings in the health system of the city we live in. We are conscious that the optimal STEACS treatment must be based on the use of networks between hospitals with different levels of complexity connected by an efficient ambulance service. (17, 22, 28) To optimize STEACS care in our community, since 2014, we have developed a SAME-connected hospital network with other hospitals that also depend of the Buenos Aires City Government and have capability to perform uninterrupted (24 h, 7 days a week) primary and rescue PCI. Since then, we have a common data registry and body of definitions, universal network performance protocols, a common planning and a result audit. This type of network reduces delays to treatment and increases the proportion of patients who receive reperfusion. (22, 29-31) We are aware that we still have to correct several things, so we consider this work as a stimulus to keep improving, with the implementation of initiatives that reduce delays, increase the attention of patients and hence, raise the quality of care.

Limitations

This study has limited influence since a selection bias of treated patients cannot be ruled out. Despite all the patients referred to the hemodynamics lab of our hospital were included in the study period, we do

not know the real incidence and the characteristics of infarctions treated with effective fibrinolysis or not treated with any reperfusion therapy in this period. Moreover, although modifications were performed in the system, its implementation was not possible from one day to the next, so many patients in G2 presented the inconveniencies observed in G1.

CONCLUSIONS

Delay to diagnosis, difficulty in communication and type of patient transfer were the main causes of delay to treatment. The implementation of a new protocol allows reducing the delay to care in STEACS patients. Continuous assessment of results, as well as permanent education of human medical-assistance resources and the society constitute the cornerstones for the optimization of this type of network programs.

Conflicts of interest

None declared.

(See authors' conflicts of interest forms on the website/ Supplementary material)

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