ORIGINAL ARTICLE

Telemedicine Network Program for Reperfusion of Myocardial Infarction

Programa en red para la reperfusión del infarto con telemedicina

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ABSTRACT

Background: Early management of myocardial infarction in the area of public health requires the integration of specific programs for the coordination of healthcare services.
Objective: The aim of this study was to evaluate the impact on delay times and reperfusion rate of a comprehensive program for the reperfusion of myocardial infarction in a hospital network of the Southern Greater Buenos Aires.
Methods: The network consists of six low-mid-complexity hospitals and a third-level referral center with 24-hour cath-lab. Stage 1 of the program (2009-2010) evaluated the existing barriers to reperfusion; Stage 2 (2011-2013) implemented the progressive incorporation of improvements and Stage 3 assessed the program (2013-2014) complemented with fellows in each hospital. Program impact was evaluated by the proportion of patients reperfused and time to its implementation.
Results: A total of 432 patients referred from the network were hospitalized with diagnosis of ST-segment elevation myocardial infarction. Mean age was 56±9 years and 83.3% were men. The proportion of reperfused patients progressively increased: S1 60.7%, S2 69% and S3 78%, p for trend=0.01. Time to reperfusion decreased significantly between S1 and S3, from 120 minutes (IQR 55-240) to 90 minutes (IQR 35-150), p=0.04, with a median reduction of 30 minutes in the door-to-balloon and door-to-needle times.
Conclusions: The application of a program for myocardial reperfusion based on the diagnosis of barriers was associated with 28.5% increase in reperfusion, and a significant reduction in the implementation times. This public network model built on algorithms adapted to local barriers may contribute to improve the care of myocardial infarction in our country.

Key words: Myocardial Infarction -Myocardial Reperfusion- Telemedicine - Community Networks

RESUMEN

Introducción: La atención del infarto en sus primeras horas en el ámbito público requiere la coordinación de los servicios asistenciales integrando programas específicos.
Objetivo: Evaluar el impacto sobre los tiempos de demora y la tasa de reperfusión de la instrumentación de un programa integral para la reperfusión del infarto en una red hospitalaria pública del conurbano sur bonaerense.
Material y métodos: La red está compuesta por seis hospitales de baja-mediana complejidad y un centro de tercer nivel con disponibilidad de hemodinamia las 24 horas. En la Etapa 1 (E1) del programa (2009-2010) se evaluaron las barreras existentes para la reperfusión, en la Etapa 2(E2) (2011-2013) se incorporaron progresivamente las medidas y en la Etapa 3(E3) (2013-2014) se evaluó el programa complementado con becarios en cada hospital. Se midió el impacto del programa en la proporción de pacientes reperfundidos y tiempos a su implementación.
Resultados: Se internaron un total de 432 pacientes derivados de la red con diagnóstico de infarto con elevación del segmento ST. Edad 56 (± 9) años, hombres 83,3%. La proporción de pacientes reperfundidos aumentó progresivamente: E1 60,7%, E2 69% y E3 78%, p de tendencia=0,01. Los tiempos a la reperfusión se redujeron significativamente entre la E1 y la E3, de 120 minutos (IIC 55-240) a 90 minutos (IIC 35-150), p=0,04, con una reducción de la mediana de 30 minutos tanto en el tiempo puerta-balón como puerta-aguja.
Conclusiones: La implementación de un programa basado en el diagnóstico de barreras se asoció con un incremento en la proporción de reperfusión del 28,5% y con una reducción significativa de los tiempos en la implementación. Este modelo de red para la atención pública basado en algoritmos adaptados a la problemática local puede contribuir a mejorar la asistencia del infarto en nuestro país.

Palabras clave: Infarto del miocardio- Reperfusión miocárdica - Telemedicina – Redes comunitarias

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Abbreviations

IQR	Interquartile range	**S2**	Stage 2
PPCI	Primary percutaneous coronary intervention	**S3**	Stage 3
S1	Stage 1	**STEAMI**	ST-segment elevation acute myocardial infarction

INTRODUCTION

Myocardial infarction is a frequent disease with elevated mortality rates. According to national statistics, 30% of deaths in Argentina can be attributed to cardiovascular causes, and in epidemiological estimations, approximately 40,000 patients per year are hospitalized for myocardial infarction. (1, 2) In the first hours after infarction different interventions have an impact on mortality reduction, the main one being reperfusion therapy. (3) Scientific publications based on multicenter registries and referral networks for the treatment of ST-segment elevation acute myocardial infarction (STEAMI) have shown suboptimal results regarding the rate of reperfused patients and the times to its implementation. (4, 5) Existing scientific evidence shows that it is necessary to develop a comprehensive plan with specific programs for STEAMI treatment to achieve a significant increase in the proportion of reperfused patients and a reduction in the times to reperfusion. (6-13) These programs require the initial diagnosis of situations and barriers, plans involving the different participants, the generation of common treatment algorithms, and the application of long-term measures with permanent evaluation of results. (6-11) In our country there is scarce experience in the elaboration of programs based on referral networks for reperfusion of STEAMI patients.

The aim of our study was thus to evaluate the impact of the progressive application of a comprehensive STEAMI reperfusion program on the ratio of reperfused patients and time delay to reperfusion in a hospital network of the Southern Greater Buenos Aires.

METHODS

An interventional study was designed with pre-and post-intervention endpoints. The hospital network was established at the onset of activities in the high complexity hospital in October 2008 and consists of another six low-mid-complexity hospitals of the Southern Greater Buenos Aires (Appendixes 1 and 2). The high-complexity hospital has a cardiovascular intensive care unit, 24-hour cath-lab with primary percutaneous coronary intervention availability, and cardiovascular surgery. In low-mid-complexity hospitals the emergency is managed by general practitioners, the intensive care units are polyvalent, and lack a proper cath-lab (see Appendix 1). All patients diagnosed with STEAMI admitted to the high-complexity hospital referred from the network hospitals between June 2009 and May 2014, were included in the study. Patients referred from centers outside the network and those who presented spontaneously to the high-complexity hospital were excluded from the analysis. The study was initiated in June 2009, when the prospective registry of acute coronary syndromes started in the high-complexity hospital, and was divided in three temporal consecutive stages. The first stage of the program (S1, June 2009 to April 2010) evaluated the existing barriers for reperfusion in the different centers. Qualitative assessments were performed by group interviews with medical directors, chief and staff physicians of the emergency departments belonging to the network hospitals, and quantitative evaluations by time delays to reperfusion during that stage. The main barriers were absence of cardiologists in the emergency rooms trained to interpret the electrocardiograms, lack of fibrinolytics in some emergency rooms, inexperience of clinicians to infuse fibrinolytics, and excessive delay in transfer times due to lack of available ambulances. In the second stage (S2, May 2010 to April 2013), the following measures were progressively implemented, based on the detected barriers and the availability of network resources: a) incorporation of a telemedicine system with available equipments in the hospital network emergency rooms for 24-hour web-based electrocardiogram transmission to the coronary care unit of the high-complexity hospital; b) theoretical-practical talks on the management of patients with chest pain and/or infarction and fibrinolytic infusion; c) an agreed algorithm for the management of patients consulting for chest pain; d) a specific algorithm for STEAMI, according to onset, extension and clinical involvement, with preference for in-situ thrombolysis, or direct referral for primary percutaneous coronary intervention (PPCI). Extensive infarctions, heart failure, cardiogenic shock or contraindication to fibrinolytic therapy were considered preferential criteria for PPCI referral; and e) a system of private ambulances was incorporated for transfer of PPCI patients in case of delay in the system service. At the beginning of the third stage (S3, May 2013 to May 2014) a physician responsible of program management was appointed at each second-level center, financed by a research scholarship for multicenter studies (Carrillo Oñativia Scolarships) of the National Ministry of Health. Since then, the program works with all the implemented measures.

The final endpoints were the rate of reperfused patients and times to reperfusion (door-to-needle and door-to-balloon times) achieved in the network.

Statistical analysis

Continuous variables were expressed as mean and standard deviation or as median and interquartile range according to their distribution. Categorical variables were expressed as numbers and percentages. Differences between groups for continuous variables were evaluated with non-parametric tests (Kruskal-Wallis). Categorical variables were compared using the chi-square and Fisher tests. The chi-squared test for trend was used to assess the temporal evolution and the rate of reperfused patients. A two-tailed p value <0.05 was considered as statistically significant for all comparisons. Statistical analyses were performed with STATA 10.0 (StataCorp LP, College Station, Texas) and Epi-Info 3.5.1. software packages.

Ethical considerations

The study was approved by our hospital Scientific Commit-

tee and Ethics Committee. An informed consent was not requested, as it was a study based on an intervention to the system and not to individual patients.

RESULTS

A total of 432 patients referred from the network with STEAMI diagnosis were admitted to hospital. Eighty-nine patients were incorporated in S1, 261 in S2 and 82 in S3. Mean age was 55.8±9.4 years and 83.3% were men. Patient flowchart is described in Figure 1. The main characteristics of the patients are detailed in Table 1.

Reperfusion

The proportion of patients who presented criteria to receive reperfusion strategies at the time of consultation in the first center was similar in the three stages: 87.6%, 87% and 87.8%, respectively, p=0.97. The overall rate of patients treated with some reperfusion strategy was 69%, and progressively increased; in S1: 60.7%, S2: 69% and S3: 78% (p for trend=0.01), with an absolute reperfusion increase of 17.3% and relative increase of 28.5% between S1 and S3 (Figure 2A).

Influence of telemedicine on reperfusion

The use of telemedicine among patients referred for reperfusion increased in the successive stages; in S1: 0%, S2: 19.9% and S3: 54.9%. Independently of the temporal stage, the proportion of reperfused patients was greater when telemedicine was used (78.4% vs. 66.3%; p=0.01).

The analysis of the association between the use of telemedicine and the rate of reperfusion stratified by stages is shown in Table 2.

Type of reperfusion

Figure 2B depicts the type of reperfusion used. It can be seen that the increase in the indication of reperfusion strategies applied both to thrombolytic therapy and PPCI.

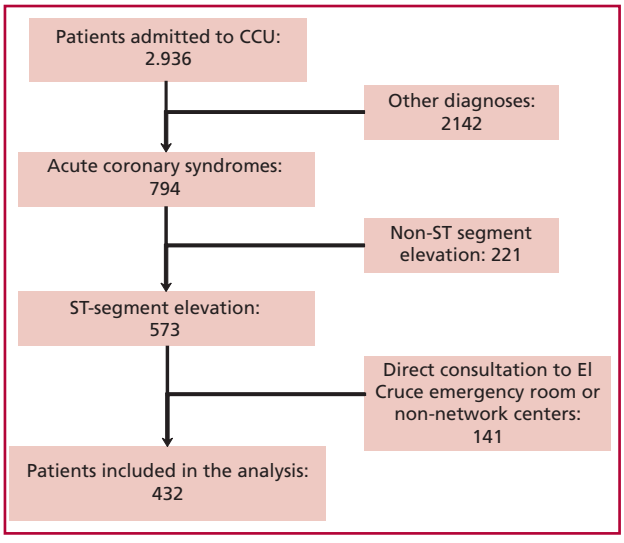

Fig. 1. Patient flowchart. CCU: Coronary care unit.

Table 1. Baseline patient characteristics

Variable	Mean	SD
Age, years	55.8	9.4
	n	%
Male gender	360	83.3
Hypertension	232	53.7
Diabetes	69	16
Hypercholesterolemia	139	32.2
Smokers	254	58.8
Previous infarction	41	9.5
Killip and Kimbal at admission *		
A	303	73.9
B	77	18.8
C	13	3.2
D	17	4.1

*Calculated on 410 patients with reported evaluation.

Times to reperfusion

Times to reperfusion were progressively reduced. The reduction was significant between S1 and S3: from a median of 120 minutes (IQR 55-240) in S1 to 90 minutes (IQR 35-150) in S3 (p=0.04). Among patients receiving fibrinolytics at the center of origin, the door-to-needle time was significantly reduced, from 75 minutes (IQR 40-194) in S1 to 45 minutes (IQR 30-90) in S3, with a median reduction of 30 minutes (p=0.035) (Figure 3A), increasing the rate of patients undergoing fibrinolysis within the recommended door-to-needle time (<30 min) from 22% in S1 to 36.7% in S3. A similar though not significant trend in door-to-balloon time reduction was observed among patients undergoing PPCI, from 210 minutes (IQR 120-300 minutes) in S1 to 180 minutes (IQR 130-245) in S3, with a median reduction of 30 minutes (p=0.67) (Figure 3B), slightly increasing the rate of patients receiving PPCI within the recommended door-to-balloon time (<90 min) from 5.3% in S1 to 5.9% in S3. The telemedicine system did not have a significant influence on the times to reperfusion (see Figure 3).

DISCUSSION

ST-segment elevation acute myocardial infarction reperfusion therapy is a medical issue that requires a public health system approach due to the necessary planning and logistics for its implementation, and the beneficial effect produced when performed correctly and within the recommended times. (3) The complexity of proper STEAMI treatment, owing to the need of staff in emergency rooms trained for diagnosis and management, accessible resources to transport patients when

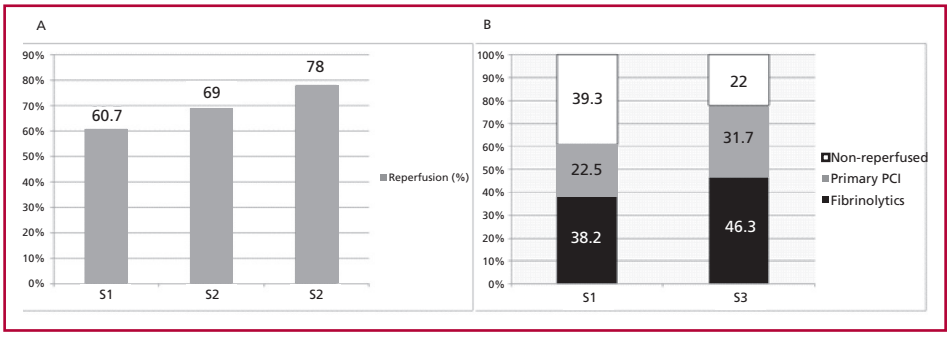

Fig. 2. A: Percent reperfusion by stages. **B:** Type of reperfusion in stages 1 and 3. S1: Stage 1, S2: Stage 2. S3: Stage 3.

Table 2. Reperfusion and use of telemedicine, stratified by stages

Stage	Use of telemedicine	Reperfused n (%)	Non-reperfused n (%)	p
1	No	54 (60.7)	35 (39.3)	-
2	Yes	40 (76.9)	12 (23.1)	0.08
	No	140 (67)	69 (33)	
3	Yes	36 (80)	9 (20)	0.3
	No	28 (75.7)	9 (24.3)	

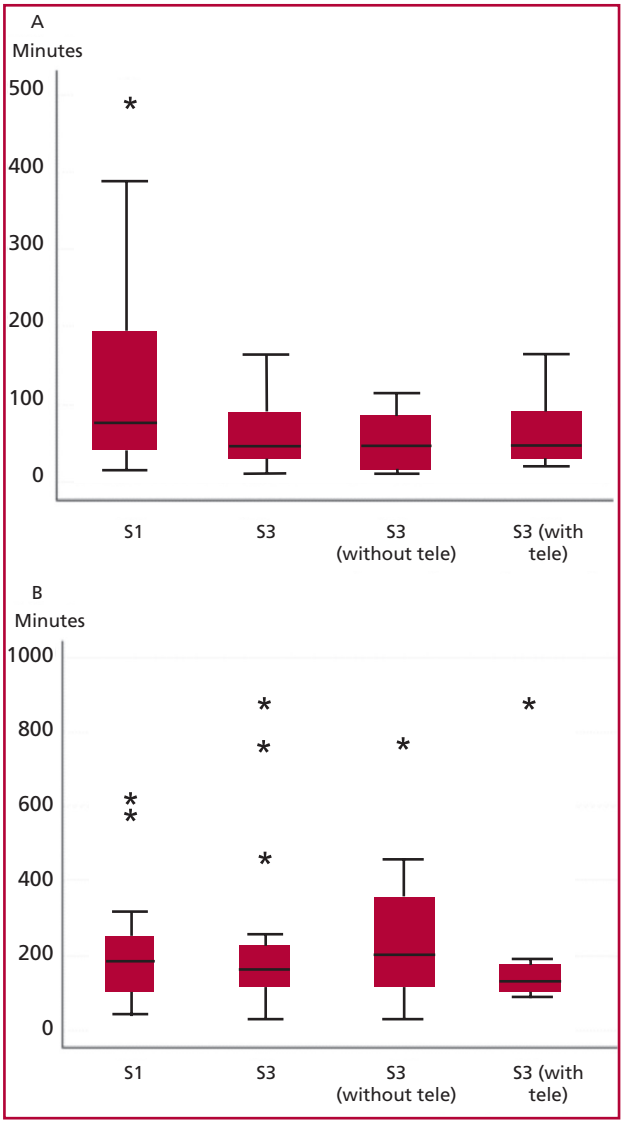

Fig. 3. Times by stages and type of reperfusion. A: Fibrinolytics. B: Primary percutaneous coronary intervention. S1: Stage 1. S3: Stage 3. S3 (without tele): Stage 3 without telemedicine. S3 (with tele): Stage 3 with telemedicine.

required, available 24-hour cath-lab for the treatment of complex cases, etc., has led to the implementation of specific programs in different parts of the world, with satisfactory results in the achievement of a significant increase in the rate of reperfused patients and a reduction in the time for its implementation. (6-13) The STEAMI treatment network program in our region has been developed following some of the concepts used in other programs, but has been adapted to the needs, barriers and resources of our network. The relatively low rate of reperfused patients and prolonged times recorded prior to the implementation of our program patently demonstrated the existence of significant barriers concerning reperfusion. In this regard, our initial results did not markedly differ from those published by other national and international studies. García Escudero et al. and Piombo et al. published the results of a reperfusion network in the City of Buenos Aires in the absence of specific community programs, and showed similar results to our initial data regarding the rate of reperfused patients and time to reperfusion with PPCI. (14-16) Other international studies also showed that in the absence of specific programs to optimize STEAMI treatment, the results were unsatisfactory. Barbagelata et al. evaluated the temporal trend of delays to reperfusion in trials published between 1993 and 2003 and verified the absence of significant improvement in the door-to-balloon time and time to reperfusion during that decade. (5) McNamara et al. evaluated the temporal evolution of time to reperfusion in myocardial infarction in the United States, and the median door-to-balloon and door-to-needle times presented less than one minute/year variation between 1999 and 2002. (4) In contrast, several publications showed improvement in reperfusion times in different myocardial infarction treatment networks. In all cases, the optimization time resulted from implementing institutional or general programs tending to shorten each stage of the reperfu-

sion process. (6-13) This scientific evidence, added to that of our study, confirms that the development and implementation of specific programs are the main tool to optimize STEAMI treatment.

The potential clinical impact resulting from the application of our program lies in two effects: a significant increase of 28.5% in the rate of reperfused patients, reaching 78% reperfused patients in S3, and a reduction of 30 minutes in door-to-balloon and door-to-needle times, achieving an absolute increase of 15.3% and relative increase of 56% in the rate of reperfused patients within the recommended times according to the reperfusion method used. We believe that the main impact of the program was based on the significant increase in the percentage of reperfused patients, since the reduction in the time to reperfusion, although significant, did not allow an increase in the percentage of reperfused patients within in-hospital recommended optimal times, even in S3. In this aspect work is still being performed on the network to optimize these times.

With regard to the method of reperfusion, the algorithm agreed with the medical network contemplates a combination of circumstances in which thrombolysis administered in the hospital of origin is the method of choice, considering its availability in all centers from the beginning of the intervention, low cost, shorter implementation time, trained personnel during the program, median difference in the implementation time >90 minutes compared with PPCI, and availability of rescue PCI in the network, not requiring times so constrained as PPCI. In patients with large infarcts, or when referral for PPCI can be done in a very short time and the time estimated between consultation and first balloon inflation is less than 90 minutes, the advantages of this methodology are scientifically undeniable. (3)

It is important to analyse the impact of telemedicine implementation. Patients in whom this system was used were more frequently reperfused than referred patients where the system was not used. Moreover, the percentage of patients reperfused with fibrinolytics in the center of origin was higher among patients in whom telemedicine was used. However, the improvement in the rate of reperfused patients may be only partially attributable to telemedicine, added to a general improvement of the system, since the increase of reperfusion (approximately 20% between the first and last stage) was greater than the difference between the telemedicine and non-telemedicine groups (10%). It should also be noted that there was also an increase in the reperfusion of patients with no telemedicine. The door-to-balloon and door-to-needle times were not modified significantly by the use of telemedicine.

In our experience the change was remarkable in the last stage with the support of the Carrillo Oñativia Scholarship, which helped finance working hours of research fellows in each of the network hospitals. Their activity was associated with a sixfold increase in the use of the telemedicine system (which will be reported separately) and a marked improvement in the times. Cultural and motivational aspects are crucial for the success of any program that focuses on improving the treatment of myocardial infarction.

Limitations

Our study has limitations that should be pointed out. The population comprised patients referred to high complexity hospitals. We cannot rule out a low percentage of non-referred STEAMI patients admitted to the lower-complexity hospitals of the network.

The survey of event times occurring in referral hospitals were conducted by patient questioning, observation of electrocardiogram times, medical records, nursing and clinical reports, and clinical referral summaries. We cannot rule out minor differences between reported and real times.

The increase in the rate of reperfusion among patients in whom the telemedicine system was used might be due to the presence of confounding variables, difficult to survey.

CONCLUSIONS

We conclude that the implementation of an acute myocardial infarction reperfusion program in a public hospital network, based on the diagnosis of existing barriers at the local level, was associated with an increase of 28.5% in the rate of reperfusion and a significant reduction in the time to its implementation. This network model for public healthcare based on algorithms adapted to local issues can help improve the treatment of myocardial infarction in our country.

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Conflicts of interest

None declared

(See author´s conflicts of interest forms in the web / Supplementary Material)

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APPENDIX 1

Second-level centers participating in the network.

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APPENDIX 2

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