Time delays in Performing Primary Angioplasty in Patients Transferred with Acute Myocardial Infarction: a Health-Care Issue

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SUMMARY

Background
It has been exhaustively proved that in patients with acute myocardial infarction (AMI) time to reperfusion is closely related to short and long-term outcomes; therefore, time between onset of symptoms and coronary reperfusion is extremely important. This time interval comprises two periods: "patient time" and "health-care time". In terms of primary angioplasty, analysis of both time intervals is a necessary step to achieve a reduction in delay to reperfusion.

Objective
The aim of this study was to analyze the time intervals in each stage of the process hospital transfer-angioplasty (either primary or rescue angioplasty) in patients with ST-segment elevation acute myocardial infarction (STEMI) transferred from a hospital with no angioplasty facilities to a tertiary medical center in the city of Buenos Aires, as a first step for implementing a time optimized program.

Material and Methods
We conducted a prospective and observational study of patients transferred to the *Hospital General de Agudos "Dr. Cosme Argerich"* for percutaneous coronary intervention (PCI) due to STEMI. Time intervals from symptoms onset until coronary reperfusion were analyzed: "patient time", defined as the time interval from onset of symptoms until arrival at the referring hospital, and "health-care time", defined as the time interval from referring hospital arrival to balloon inflation.

Results
The study included 313 patients; 225 (72%) underwent primary angioplasty (PPTCA) and rescue angioplasty (RPTCA) was performed in 88 patients (28%). Median (quartile) time intervals in PCI patients were as follows: patient time: 90' (40-240); referring hospital arrival (RH) -emergency interventional cardiology team (EICT) activation time: 80' (35-150); EICT activation-admission to cardiac catheterization laboratory time: 75' (55-100); admission to cardiac catheterization laboratory time -balloon time: 35' (23-52); medical care time: 220' (142-290); ambulance transport time: 31' (26-40). Median (quartile) time intervals in RPCI patients were as follows: patient time: 90' (30-120 RH arrival -EICT activation time: 180' (120-245); EICT EICT activation-admission to cardiac catheterization laboratory time: 85' (60-115); admission to cardiac catheterization laboratory time -balloon time: 40' (26-61), medical care time: 297' (230-395); ambulance transport time: 34' (28-44).

Conclusions
"Patient time" interval accounts for approximately one third of the total time. "Medical care time" is the main cause related to time delay in starting the procedure. Reduction in time delays might only be achieved by implementing a program focused on multifactor and interdisciplinary strategies.

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Key words > Myocardial infarction - Time - Angioplasty

Abbreviations >

PPTCA	Primary percutaneous transluminal coronary angioplasty	**EICT**	Emergency Interventional Cardiology Team
RPTCA	Rescue percutaneous transluminal coronary angioplasty	**RH**	Referring hospital
CABA	Autonomous City of Buenos Aires	**AMI**	Acute myocardial infarction
ECG	Electrocardiogram	**STEMI**	ST-segment elevation myocardial infarction
		SAME	*Sistema de Atención Médica de Emergencias*

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BACKGROUND

Reperfusion therapy improves the prognosis of patients with ST-segment elevation myocardial infarction (STEMI) by reestablishing coronary flow in the culprit vessel. Time to reperfusion influences short-term and long-term outcomes. Primary percutaneous transluminal coronary angioplasty (PPTCA) is more effective then fibrinolytic therapy in patients with STEMI. (1-5) At present, indication of PPTCA is increasing and is used more frequently than thrombolysis. (6-8)

Transportation of patients to centers with angioplasty facilities has proved to be safe, and better survival rates are achieved when the patient arrives at the referral center in less than 120 minutes. (9-11)

The main limiting factors to perform coronary angioplasty include availability of PTCA facilities, material and well-trained staff to perform the procedure rapidly.

In our country there is no information regarding the characteristics of the population and time delays in the transportation of patients to undergo PPTCA. The periodical surveys carried out by the Argentine Society of Cardiology (SAC) represent an important effort to clear the strategies used in Argentina; however, this particular issue has not been analyzed yet. (7, 12)

Although there are no reliable data of the prevalence of acute myocardial infarction (AMI) in our country, the annual risk might be about 9 per 10000 inhabitants. (13)

The aim of this study was to analyze the time intervals in each stage of the process hospital transfer-angioplasty (either primary or rescue angioplasty) in patients with STEMI transferred from a hospital with no angioplasty facilities to a hospital with angioplasty availability in the Autonomous City of Buenos Aires (CABA, *Ciudad Autónoma de Buenos Aires*) as a first step for implementing a time optimized program for patient transportation.

MATERIAL AND METHODS

The study population consists of patients transferred from public and private hospitals of the CABA and the suburbs of the city. The coordination of communications and patients' transportation were performed by the emergency medical system (SAME, *Sistema de Atención Médica de Emergencias*) of the CABA.

At present, the CABA does not have a medical program involving the SAME or the coronary care units. The strategy used depends on the criterion of the attending physician.

From January 1, 2004 to December 31, 2007, 313 patients with suspected STEMI referred for angioplasty (PTCA) were prospectively included. A specially designed questionnaire was completed by the interventional cardiology team and data were introduced in Epi info 6.0 databases for further analysis.

Patients were transported by mobile coronary care units or ambulances that belonged to the RH or to the SAME.

Patients had arrived at the Emergency Department of the RH by self-transport or had been transported by ambulance from their homes. The attending physician informed the SAME about the need of PTCA; the SAME called up the interventional cardiologist who activated the Emergency Interventional Cardiology Team (EICT) which included the interventional cardiologist, a nurse and a catheterization laboratory technician.

Patients were eligible according to the American College of Cardiology/American Heart Association class I recommendations (14):

- Angina-like chest pain or other symptoms suggestive of myocardial ischemia lasting more than 30 minutes.
- ST-segment elevation e" 0.1 mV in at least two consecutive leads or new (or presumably new) left branch bundle block (LBBB) within 12 hours after symptoms onset.

Patients already admitted at the moment of symptoms onset were not included in this analysis.

Primary PTCA was defined as the one performed in absence of previous administration of thrombolytic agents and rescue angioplasty (RPTCA)) was defined as angioplasty performed after failed fibrinolytic therapy (100% streptokinase).

Variables

The following variables were analyzed:

- Demographic data and basal clinical characteristics.

Time intervals (in minutes) were defined as (Table 1 and Figure 1):

- **Patient time:** from the onset of symptoms to RH arrival.
- **Medical care time:** from arrival at the RH until first balloon inflation. In turn, this time interval included three intervals:
  Time 1: RH arrival-EICT activation.
  Time 2: EICT activation-admission to cardiac catheterization laboratory.
  Time 3: admission to cardiac catheterization laboratory-first balloon inflation.

Table 1. Definition of the time intervals analyzed

Patient time	Symptoms onset-to-RH arrival
Medical care time	RH arrival-to-first balloon inflation (includes time 1, 2 and 3).
Time 1	RH arrival-EICT activation
Time 2	EICT activation-admission to cardiac catheterization laboratory
Time 3	Admission to cardiac catheterization laboratory-first balloon inflation
Door-to-door	RH arrival-admission to cardiac catheterization laboratory (includes time 1 and 2)
Activation-to-balloon	EICT activation-first balloon inflation (includes time 2 and 3)
Pain-to-balloon	Symptom onset-first balloon inflation
Transport	Time duration of ambulance transportation

RH: Referring hospital EICT: Emergency Interventional Cardiology Team.

Other time intervals analyzed were:

- **Door-to-door time:** RH arrival-admission to cardiac catheterization laboratory (includes time 1 and 2).
- **Activation-to-balloon time:** EICT activation-first balloon inflation (includes time 2 and 3).
- **Pain-to-balloon time**: symptom onset-first balloon inflation.
- **Transport time:** time duration of ambulance transportation.

Time intervals were calculated as follows:

- Time from symptoms onset and RH arrival were determined based on patients or relatives interview.

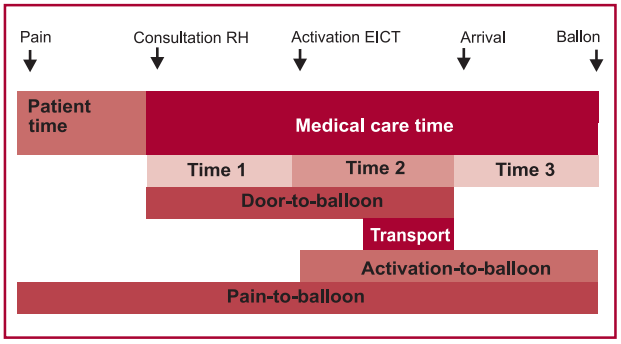

Fig. 1. Time intervals analyzed.

- Activation time refers to the moment of the telephone call between the RH and the EICT registered by the interventional cardiologist.
- Ambulance departure time: obtained by the referring physician.
- Admission to the cardiac catheterization laboratory: time recorded by the EICT.
- First balloon inflation: recorded by the cardiac catheterization technician.

Statistical Analysis

Qualitative variables were expressed as absolute values and percentages, and quantitative variables as means with their corresponding standard deviations. Time intervals were expressed as median and interquartile interval. The analysis of qualitative variables was performed using chi-square test; Student's *t* test was used for normal distributions of quantitative variables and Kruskall-Wallis test for non parametric distributions of quantitative data.

RESULTS

A total of 313 patients underwent PTCA, (PPTCA 225 [72%] and RPTCA 88 [28%]). Patients' demographic and clinical characteristics are described in Table 2.

For PPTCA: patient time 90 minutes (40-240); time 1: 80 minutes (35-150); time 2: 75 minutes (55-100); time 3: 35 minutes (23-52); medical care time: 200 minutes (142-290). Pain-to-balloon time: 283 min-

Table 2. Basal and angiographic characteristics

	Primary (n = 225)	Rescue (n = 88)	p
Age	57.8 ± 11.5	57.2 ± 10.2	ns
Male gender	187 (83.1%)	71 (80.7%)	ns
Age > 75 years	18 (8%)	6 (6.8%)	ns
Anterior wall	121 (54%)	38 (44.2%)	ns
Hypertension	119 (52.9%)	38 (44.2%)	ns
Diabetes	36 (16%)	16 (18%)	ns
Current smoking	151 (67%)	64 (72.8%)	ns
Dyslipemia	99 (44%)	40 (45.5%)	ns
Family history	47 (21%)	23 (26%)	ns
Overweight	106 (47%)	39 (44.4%)	ns
Sedentary life	162 (72%)	67 (76.2%)	ns
Previous AMI	52 (23%)	12 (13.6%)	ns
Shock (referral center)	15 (11.5%)	11 (12.5%)	ns
Heart failure (referral center)	43 (19%)	17 (19.3%)	ns
Transferred from the ED	187 (83%)	42 (48%)	< 0.00001
Transferred from CCU-ICU	38 (17%)	46 (52%)	< 0.00001
Patients with social security coverage	56 (25.5%)	24 (27.9%)	ns
Patients from the CABA	157 (71.4%)	67 (76.1%)	ns
One-vessel coronary artery disease	104 (46.2%)	36 (41%)	ns
Two-vessel coronary artery disease	60 (26.6%)	30 (34%)	ns
Three-vessel coronary artery disease	61 (27.1%)	22 (25%)	ns
Success	206 (91.6%)	73 (83%)	ns

utes (219-420), activation-to-balloon time: 115 minutes (90-148), and transport time: 31 minutes (26-40) (Figure 2).

For RPTCA: patient time 90 minutes (30-120); time 1: 180 minutes (120-245); time 2: 85 minutes (60-115); time 3: 40 minutes (26-61); medical care time: 297 minutes (230-395). Pain-to-balloon time: 390 minutes (245-438), activation-to-balloon time: 118 minutes (95-155), and transport time: 34 minutes (28-44) (Table 3).

There were no significant differences in PTCA outcomes differences between patients admitted on weekdays, weekends, regular hours and off-hours (Table 4).

DISCUSSION

This registry shows our contemporary data of patients with STEMI transferred to a center with angioplasty facilities to undergo PPTCA or RPTCA in the CABA.

Time from symptoms onset to coronary reperfusion in STEMI patients is crucial to define a treatment strategy. This time interval includes "patient time" and "medical care time". The analysis of this time interval with its corresponding periods is a necessary step for optimizing PPTCA.

The patient time (90 minutes) is lower than the one previously reported in other registries (12, 15-18) (Table 5).In addition, 75% of patients arrived within 3 hours from symptom onset.

In the Transfer AMI trial, (15) the total time interval from symptom onset to STEMI diagnosis was 177 minutes. These intervals were longer even in cases of specifically designed programs and in a few trials. (19-21)

The SAC survey reported a time interval of 240 minutes, which might be due to the fact that STEMI was present in only 80% of the patients included. (12)

The medical care time starts after the initial consultation. The potential points of delay in the time to reperfusion can be divided in three time intervals: a) RH arrival to diagnosis of AMI, choice of treatment strategy and EICT activation (time 1), b) time 2, and, c) time 3.

a) Time 1: in our population this median time of 80 minutes was prolonged.

This might be due to several reasons which were not surveyed. The absence of systems of care for patients with chest pain presenting to waiting rooms and examination rooms at the emergency department, the lack of a treatment algorithm for STEMI, the difficulties to activate the EICT and low training levels among physicians, are some of the reasons for this delay. A reduction in this time interval might allow detecting a greater number of patients who might benefit from on site fibrinolysis.

This delay might also be due to a population bias. The study population is not representative of all STEMI patients arriving at the emergency department, as subjects included were selected for PPTCA. According to basal characteristics they were high risk patients. Although patients were younger than those included in other trials and registries, the prevalence of anterior infarction, previous AMI, diabetes, heart failure and cardiogenic shock was greater. (9, 10, 15-17, 22) In fact, the high prevalence of cardiogenic shock (11.5%) might account for additional delays associated with stabilization of patients before transportation.

The diagnosis of AMI should be made rapidly at the Emergency Department in order to initiate the adequate reperfusion therapy as soon as possible. The maximum time interval between hospital arrival, history taking and obtaining a 12-lead electrocardiogram should not be greater than 10 minutes. (23, 24) Despite this recommendation, several studies have reported that ECG is acquired later in routine practice. (24)

b) Time 2: once STEMI has been diagnosed, it is essential to initiate the reperfusion therapy rapidly. We are not aware of the presence of registries on this issue in our country. In our case, time interval to PPTCA is 75 minutes. The net transportation time from the RH Emergency Department to the catheterization laboratory is 31 minutes. The rest of the time is taken by the SAME in organizing patient transportation, which may be performed by an ambulance belonging to the RH, to the SAME or by a Coronary Care Unit. The last two situations increase the time

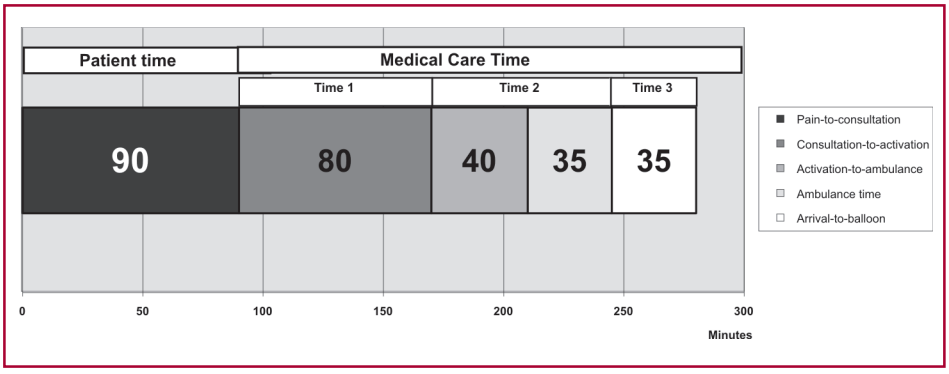

Fig. 2. Time delays in the different intervals analyzed in patients undergoing primary angioplasty.

delay due to the fact that an ambulance has to move to the RH. The lack of standard protocols defining how patients should be transferred, which conditions have more priority at the moment of transportation, and the fact that cardiologists and heads of the emergency departments are reluctant to use the ambulances of the RH for patient transportation are some of the issues related with this delay.

In the Transfer AMI trial, this time interval was 90 minutes. (15) This information is not available in other registries and, thus, cannot be compared.

c) Time 3: 35 minutes, similar to the results previously reported (Transfer AMI 35', NRMI 53'). (15, 16) Yet, it might be improved using systems of care in the reception and preparation of the patient.

Medical care time was 200 minutes for PPTCA in our study. These data are consistent with those of other registries. In the United States, median door-to-door delay was 180 minutes; in only 4% of cases it was lower than 90 minutes and in only 15% it was lower than 120 minutes. (25) The most important delays occurred in patients with comorbidities, in those presenting late after the onset of symptoms, outside daytime working hours or in rural areas, and with unspecific findings in the ECG. (25) In our case, there were no statistically significant differences in time delays observed during weekdays, weekends, regular hours and off-hours.

These findings are similar to those observed in other national registries evaluating PPTCA in STEMI in the real world (15-18) (Table 5).

Table 3. Time intervals in minutes

Variable	Primary (n = 225; 72%)	Rescue (n = 88; 28%)
Patient time	90 (40-240)	90 (30-120)
Medical care time	200 (142-290)	297 (230-395)
Time 1	80 (35-150)	180 (120-245)
Time 2	75 (55-100)	85 (60-115)
Time 3	35 (23-52)	40 (26-61)
Door-to-balloon	283 (219-420)	390 (245-438)
Activation-to-balloon	115 (90-148)	118 (95-155)
Door-to-door	160 (100-240)	255 (185-345)
Transport time	31 (26-40)	34 (28-44)

Measures to be adopted

Although "patient time" is lower compared to similar registries, it is necessary to implement periodical plans focused on educating the population about the importance of seeking medical care rapidly.

Time from symptoms onset until arrival at the place of the first medical contact will define the reperfusion strategy to minimize time to reperfusion. In patients arriving at the emergency department by self-transport, the following measures may reduce the initial delay: the implementation of warning signals in the waiting room to avoid long delays to physician assessment; early ECG acquisition in patients with typical or atypical chest pain, specially in the elder and in women; ECG should be interpreted by a cardiologist present at the emergency department or it may be wireless transmitted to the specialist; the physicians on duty should review systematically the duration of the time intervals until ECG is taken and STEMI diagnosed in order to control and optimize the outcomes of these actions.

In the case of patients evaluated in the field, directed questioning, ECG taking and immediate transfer to a catheterization laboratory are measures that will optimize time to reperfusion. (19, 20)Yet, even in the United States, where about 90% of emergency medical services have 12-lead ECG equipment available in their ambulance systems, prehospital ECGs are taken in only 5% of patients. (26) Prehospital diagnosis should reduce door- to-balloon time by 20 to 50 minutes. (26-29) In this well-developed prehospital system, 60% of patients with STEMI presented to the

Table 4. Primary angioplasties, distribution according to the moment of presentation

	Weekdays			Weekends		
	Day	Night	p	Yes	No	p
Number	99	60		66	159	
Patient time	90 (37-240)	80 (30-180)	ns	90 (30-180)	90 (30-225)	ns
Medical care time	195 (128-247)	185 (139-287)	ns	200 (163-284)	194 (134-290)	ns
Time 1	60 (30-150)	82 (32-140)	ns	85 (50-145)	73 (30-150)	ns
Time 2	77 (50-110)	75 (65-90)	ns	77 (60-100)	75 (55-105)	ns
Time 3	36 (22-52)	35 (25-55)	ns	30 (23-52)	36 (25-55)	ns
Pain-to-balloon	281 (219-452)	277 (210-374)	ns	265 (200-355)	280 (228-420)	ns
Activation-to-balloon	116 (89-150)	114 (95-149)	ns	124 (90-145)	115 (91-150)	ns
Door-to-door	150 (92-236)	160 (100-245)	ns	165 (110-255)	155 (95-240)	ns

Table 5. Comparison with published registries

	Patient time	Time 1	Time 2	Time 3	Pain-to-balloon	Medical care time	Activation-to-balloon	Door-to-door	Transport time
Hospital Argerich PPTCA	90 (40-240)	80 (35-150)	75 (55-100)	35 (23-52)	283 (219-420)	200 (142-290)	115 (90-148)	160 (100-240)	31 (26-40)
Hospital Argerich RPTCA	90 (30-120)	180 (120-245)	85 (60-115)	40 (26-61)	390 (245-438)	297 (230-395)	118 (95-155)	255 (185-345)	34 (28-44)
SAC 2005 (12)	240 (120-660)	_	_	_	_	_	_	_	_
Transfer AMI (15)	177	47	90	35*	302*	_	_	_	_
NRMI-3/4 (16)	_	_	_	53	_	180	_	120	_
FAST-MI (17)	180 (116-332)	_	_	_	425 (279-701)	110* (approximately)	_	_	_
Swedish Registry (18)	_	_	_	_	210† (135-334)	_	_	_	_

PPTCA: Primary angioplasty. RPTCA: Rescue angioplasty
* Time to arterial puncture
† Time to femoral anesthesia

emergency department by self-transport and 40% called the emergency medical services. (30) Some of the limitations of this strategy are related to the incremental cost to upgrade prehospital ECG equipment to wireless capability, the necessity to train physicians/paramedics and/or to organize systems for ECG interpretation. First medical contact to balloon time was 69 minutes in programs that transport the patient from the first medical contact directly to the catheterization laboratory and 129 minutes in cases of interhospital transfer. (19, 20)

The use of ambulances from the RH might optimize transport time. In our environment, such a modality has low incidence of complications, as we have previously reported. (11)

Patients in our study sought medical advice in a rapid and adequate fashion; the greatest delays were produced by the medical care time, specially in two time intervals that should be reduced: firstly, time to diagnosis of STEMI, and secondly, time to initiate patient transportation.

Study Limitations

Patients included in this registry do not represent the whole population of STEMI patients presenting to hospitals; they are not involved in a treatment program of the disease and/or hospital transfer; in fact, the attending physicians decided that they would benefit from a PTCA. The reasons to choose this strategy are not clear according to the data of the study (characteristics of the population, delays in presentation or in diagnosis) Secondly, given the lack of a systematic program of interhospital transfer with proved efficiency, time delays are likely to be improved.

CONCLUSIONS

"Patient time" interval accounts for approximately one third of the total time. "Health-care time" is the main cause related to time delay in starting the procedure.

Reduction in time delays might only be achieved by implementing a program focused on multifactor and interdisciplinary strategies.

RESUMEN

Demoras en la realización de la angioplastia primariaen los pacientes trasladados con infarto agudo de miocardio: un problema médico-asistencial

Introducción

En el infarto agudo de miocardio (IAM) está comprobado que cuanto más tempranamente se realice la reperfusión, mejores serán sus resultados a corto y a largo plazos, por lo que el tiempo entre el inicio de los síntomas y la reperfusión coronaria es un elemento de gran importancia en la estrategia de su tratamiento. Este lapso se encuentra conformado por dos períodos: "tiempo paciente" y "tiempo médico-asistencial". En la angioplastia primaria, el análisis de estos tiempos y sus intervalos es el paso obligado para lograr una reducción de la demora a la reperfusión.

Objetivos

Analizar los tiempos en cada etapa del proceso traslado-realización de una angioplastia, ya sea primaria o de rescate,

en pacientes con infarto agudo de miocardio con elevación del segmento ST (IAMEST) que debieron ser trasladados desde un hospital derivador a un centro de referencia en el ámbito de la ciudad de Buenos Aires para someterse al procedimiento, como primer paso para un programa de optimización de los tiempos.

Material y métodos

Estudio prospectivo, observacional, de pacientes derivados al Hospital General de Agudos "Dr. Cosme Argerich" con diagnóstico de IAMEST e indicación de ATC. Se analizaron los tiempos parciales desde el inicio de los síntomas hasta la reperfusión coronaria, para lo cual se consideró "tiempo paciente" desde el inicio de los síntomas hasta la llegada al hospital derivador y "tiempo médico-asistencial" al comprendido entre la llegada al hospital derivador y la insuflación del balón.

Resultados

Se incluyeron 313 pacientes, 225 (72%) con angioplastia primaria (ATCP) y 88 (28%) con angioplastia de rescate (ATCR). Las medianas (cuartiles) de tiempo en ATCP fueron: tiempo paciente: 90' (40-240), llegada al hospital derivador-llamada al Equipo de Hemodinamia Cardiovascular de Urgencia (EHCU): 80' (35-150), llamada EHCU-ingreso hemodinamia: 75' (55-100), ingreso hemodinamia-balón: 35' (23-52), tiempo médico-asistencial: 200' (142-290), tiempo traslado ambulancia: 31' (26-40). Las medianas (cuartiles) de tiempo en ATCR fueron: tiempo paciente: 90' (30-120), llegada al hospital derivador-llamada EHCU: 180' (120-245), llamada EHCU-ingreso hemodinamia: 85' (60-115), ingreso hemodinamia-balón: 40' (26-61), tiempo médico-asistencial: 297' (230-395), tiempo traslado ambulancia: 34' (28-44).

Conclusiones

El "tiempo paciente" comprende aproximadamente un tercio del tiempo total empleado. El "tiempo médico-asistencial" constituye el principal responsable del retraso al procedimiento. La reducción de las demoras sólo será efectiva si se encara a través de un programa que contemple un enfoque multifactorial e interdisciplinario.

Palabras clave > Infarto del miocardio - Tiempo - Angioplastia

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