Implementation of the Myocardial Infarction System of Care in City of Belo Horizonte, Brazil

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Abstract

Background: The creation of an acute myocardial infarction (AMI) management systems is aimed at optimizing the management of patients from early diagnosis to proper and timely treatment.

Objective: To assess the implantation of an AMI management system in the municipality of Belo Horizonte, state of Minas Gerais, and its impact on in-hospital mortality due to AMI.

Methods: The AMI management system was implanted in the municipality of Belo Horizonte between 2010 and 2011, aiming at increasing the access of patients of the public health system to the treatment recommended by the existing guidelines. The teams at the prompt care units were trained, and the system of tele-electrocardiography was implanted in those units. The primary outcomes of this retrospective observational study were the number of admissions and in-hospital mortality due to AMI, from 2009 to 2011.

Results: In the period studied, 294 professionals were trained and 563 electrocardiograms (ECGs) transmitted from prompt care units to coronary units. A significant reduction was observed in the in-hospital mortality rate (12.3% in 2009 versus 7.1% in 2011, $p < 0.001$), while the number of admissions due to AMI remained stable. The mean cost of admission increased (mean R$ 2,480.00 versus R$ 3,501.00; $p < 0.001$), the proportion of admissions including intensive care unit stay increased (32.4% in 2009 versus 66.1% in 2011; $p < 0.001$), and the number of patients admitted to tertiary hospitals increased (47.0% versus 69.6%; $p < 0.001$).

Conclusion: The AMI management system implantation increased the access of the population to proper treatment, thus reducing in-hospital mortality due to AMI. (Arq Bras Cardiol. 2013; [online].ahead print, PP.0-0)

Keywords: Myocardial infarction / mortality; Myocardial infarction / therapy; Emergency Medical Services; Intensive Care Units.

Introduction

Over the past decades, an important reduction in the mortality rate of cardiovascular diseases has been observed, related to advances in primary prevention and treatment of acute coronary syndrome (ACS)[1-4]. Although a worldwide trend, this reduction has been more pronounced in developed countries, as more timely treatment is available, including reperfusion by primary angioplasty or fibrinolysis, dual antithrombotic therapy and critical care.

In Brazil, cardiovascular diseases remain the major cause of proportional mortality, and accounted for 29% of the deaths in 2010 (Department of Information Technology of the Brazilian Unified Health Care System [Datasus]). Acute myocardial infarction (AMI) is the second most frequent cause of death (7%, Datasus 2010). In the Brazilian public health system, the AMI in-hospital mortality remains persistently elevated: on average, 16.2% in 2000, 16.1% in 2005, and 15.3% in 2010 for all admissions in the entire country (Datasus). The elevated mortality in the Brazilian public health system has been attributed to difficulties experienced by AMI patients to have access to intensive care, reperfusion methods and the therapeutic measures established for AMI[5].

Recognizing that the proper treatment for AMI requires the interaction of several sectors [community, emergency care units (ECU), emergency transportation service, and hospital with a catheterization laboratory and intensive care unit] has induced the creation of AMI systems of care to optimize patient's care, from early diagnosis to timely treatment[6-9]. Most experiences reported have been developed in North-American and European countries, while descriptions of experiences in developing countries, such as Brazil, are rare.

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The objective of this study is to asses the establishment of the AMI System of Care of the City of Belo Horizonte, the capital of the State of Minas Gerais, and its impact on AMI in-hospital mortality.

Methods

This is a retrospective observational study carried out in the city of Belo Horizonte, whose population in 2009 was 2,452,617 inhabitants[10].

The city is organized is organized in regionals, as shown in Figure 1. The Mobile Emergency Care Service (SAMU) provides pre-hospital care for urgency and emergency cases and operates with 18 Basic Support Units (BSU) and 6 Advanced Support Units (ASU). The Medical Regulatory Centre is the coordinating and instructing element of the system, which organizes the relationship between the various services and qualifies its flow.

Each regional has a referral center for pre-hospital care, the ECU. In addition, there are urgent entry points to the hospital and tertiary hospitals specialized in cardiology (THC) spread throughout the city.

Creation of the AMI System of Care in the City of Belo Horizonte

Aiming at increasing the access of patients of the Brazilian Unified Health Care System (SUS) to the treatment recommended in existing guidelines[11-13], the Municipal Health Department of Belo Horizonte (MHD-BH) established a flowchart for patients with ACS in need for emergency services, with the support of Samu and participation of the University Hospital of the Universidade Federal de Minas Gerais (HC/UFMG), comprising the Telehealth Centre, the Cardiology and Cardiovascular Surgery Service, and the Interventional Cardiology Department of that hospital. The HC/UFMG, a hospital with catheterization laboratory, opened a Coronary Care Unit (CCU) in March 2010. In October 2011, the Hospital Santa Casa de Misericórdia began to integrate that flowchart, by making available its catheterization laboratory and CCU beds. The objective of the CCU is to ensure the timely acceptance, through transference, of patients with ACS admitted to emergency care units of the SUS-BH network and to provide, in addition to the treatment recommended by the guidelines for ACS and monitoring in an intensive care setting, access to primary and rescue percutaneous coronary intervention (PCI), when indicated. Patients with ACS can also be transferred to the THC of the SUS-BH network, which differs from the CCU by not providing access to primary and rescue PCI (or urgent PCI).

Implantation of the tele-electrocardiology system

In the management of patients with ACS and ST-segment elevation, performing pre-hospital electrocardiography (ECG) in addition to the early activation of the catheterization laboratory represents an important strategy to reduce the door-to-balloon time, with a significant reduction in mortality[14-19].

The implementation of the tele-electrocardiology system was an important component of the AMI system of care. The tele-electrocardiology system was established by Telehealth

Figure 1 – *Regionals of the municipality of Belo Horizonte. Each regional has one prompt care unit.*

Network of Minas Gerais (TNMG) with the support of the MHD-BH. The TNMG is a telecare service formed by a partnership between six universities of the state of Minas Gerais, and coordinated by the Telehealth Centre of the HC/UFMG[20]. The service began in 2005 and has already performed more than 1,000,000 digital ECGs[21].

Digital electrocardiographs were installed in seven ECUs, connected to computers. The analysis software was installed in the CCUs. After performing the ECG, the exam can be transmitted to either CCUs, if the case is an ACS with ST-segment elevation, or to the cardiology service of the TNMG, if an ECG report is required.

To ensure proper transmission, the quality of the signal emitted was tested in each ECU. The ECG transmission is immediate, through the internet, and is identified at the CCUs by the emission of a sound signal.

Training and motivating the teams

The following training and motivation strategies were developed for the ECU teams:

- visits to the ECUs to provide information about the operational flow and potential benefits of the establishment of the AMI system of care;
- multidisciplinary training of the ECU teams regarding the approach of a patient with chest pain, ACS, and the use of the digital electrocardiograph (Figure 2);
- disclosure of the Clinical Protocol on ACS of the Health Department of the State of Minas Gerais[22];

• continued supervision by use of weekly telephone monitoring, in which the existence of problems in the digital ECG transmission or the need for new trainings are assessed. Technical problems are solved by the information technology team within 24 hours. Problems of infrastructure and internet are referred to the MHD-BH.

Operational flow

Considering the patient's clinical context and the health care system, an operational flow for the establishment of the AMI system of care (Figure 3).

When ACS with ST-segment elevation is suspected, the physician of the ECU starts the initial management for ACS treatment, performs a digital ECG, which is sent to the CCU, and contacts the CCU physician using a mobile phone. The latter assesses the ECG (Figure 4), and, if the diagnosis of ACS with ST-segment elevation is confirmed, the patient may follow either the rapid care path or the MHD-BH Admission Centre care path. At other emergency units with no digital ECG, the physician should call the CCU to discuss the case.

When the chest pain has initiated more than 3 hours and less than 12 hours before, or more than 12 hours before but is recurrent or refractory, or in the presence of cardiogenic shock, the patient should follow the rapid path, being referred by the SAMU directly to the catheterization laboratory for primary angioplasty, reducing the delay for reperfusion. When chest pain has initiated less than 3 hours before, the ECU physician is instructed to administer the thrombolytic agent, except when contraindicated, and then to transfer the patient as soon as possible to the CCU or THC. That transfer is regulated by the Admission Centre. However, when neither clinical (pain relief and hemodynamic stability) nor electrocardiographic (50% reduction in the ST-segment elevation in the lead with the greatest elevation, 90 minutes after thrombolytic therapy is initiated)[23] reperfusion criteria are met after the thrombolytic infusion, the CCU should be contacted again and the patient transferred via the rapid path for rescue angioplasty.

In the presence of ACS without ST-segment elevation, the patient is registered at the Admission Centre, which refers the patient to the CCU or THC. Transference to the CCU is preferential for patients at high or intermediate risk of adverse cardiovascular events, identified by the presence of high levels of myocardial necrosis markers or depression of the ST segment compatible with myocardial ischemia, or by the TIMI or GRACE risk scores[13].

Aiming at the continued care of patients with ACS, ward beds and outpatient clinics for post-AMI care are provided to those patients for six-month follow-up, during which cardiovascular risk stratification is continued and secondary prevention of new events is performed. In addition, there is the opportunity of follow-up at a cardiovascular rehabilitation center or a smoke cessation outpatient clinic in certain cases[24]. After six months, the patient is referred for primary care or to a cardiologist of the SUS-BH health care network.

Outcomes

The outcomes were the number of admissions due to AMI and AMI in-hospital mortality assessed from 2009 (baseline) to 2011. Data from the Hospital Information System (HIS) on the procedure "treatment of AMI", code SIH/DATASUS 03.03.06.019-0, were used. That procedure was considered the one that best represented the cases related to coronary events and that encompassed the most severe cases. The percentage of hospitalizations due to AMI involving intensive care unit (ICU) stay and the percentage of authorizations of hospital admission (AHAs) to THC have also been obtained from the HIS. The population of the city for the years studied has also obtained from Datasus.

Statistical analysis

The epidemiological data generated by the HIS/Datasus were introduced in a database and analyzed by using the statistical package SPSS 20.0 (IBM Corporation, 2011). Categorical variables were described by use of frequency

Figure 2 – *Training of professionals of coronary care units to perform and transmit digital electrocardiograms*

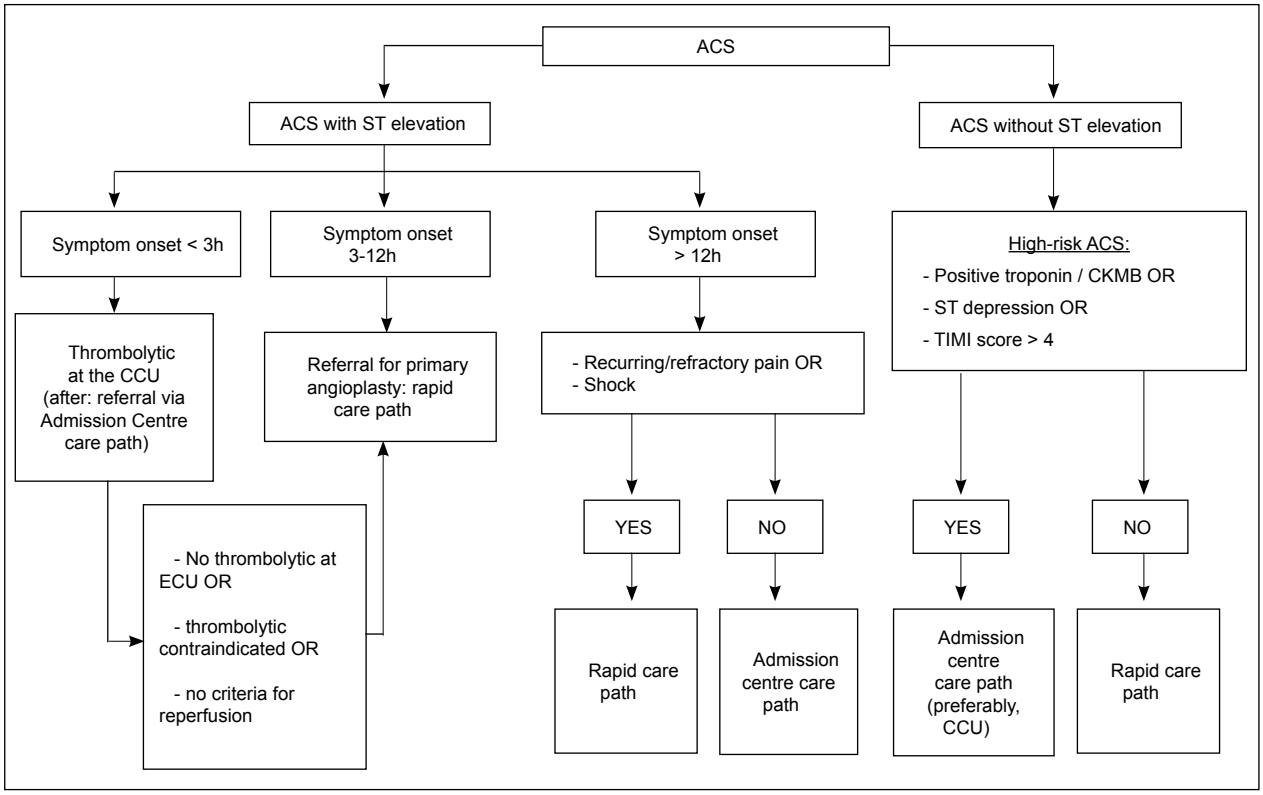

Figure 3 – *Operational flowchart for managing patients with acute coronary syndrome in the city of Belo Horizonte. ACS: acute coronary syndrome; CKMB: creatine phosphokinase MB fraction; CCU: coronary care units.*

distribution, and quantitative variables, by use of mean and standard deviation or median and interquartile range. The proportions, means and medians of independent and dependent variables in the period assessed (2009 to 2011) and between the groups (AHAs with and without ICU cost per day) were compared by use of appropriate statistical tests, including the chi-square, the Student *t*, and the Kruskal-Wallis tests. A p value ≤ 0.05 was considered statistically significant.

Figure 4 – *Analysis of the digital electrocardiogram of a case of acute coronary syndrome with ST-segment elevation by the coronary care unit physician.*

Results

The tele-electrocardiology system was established in the first PCU in January 2011. From January to December 2011, 294 professionals were trained and 1,496 ECGs were transmitted as follows: 563 (37.6%) to COUs and 933 (62.4%) for report. A great variation in the number of ECGs per PCU was observed, and the Centro-sul (66.0%), Leste (12.0%) and Venda Nova (9.8%) ECUs performed more exams.

Table 1 shows the indicators selected from 2009 to 2011. Analyzing the temporal trend, the demographic characteristics were similar, with mean age around 60 years, and male sex predominance. The number of hospital admissions remained relatively stable over the period analyzed, ranging from 1,113 to 1,358. The mean hospital length of stay did not differ statistically over the years. However, there was an expressive reduction in the AMI in-hospital mortality rate: from 12.3% in 2009 to 7.1% in 2011, reaching statistical significance ($p<0.001$).

In addition, the mean admission cost almost doubled during a time in which no significant readjustment in the prices of the SUS procedures occurred, which is an indirect indicator of greater access to the THC. There was an increase in the percentage of admissions including ICU stay (from 32.4% in 2009 to 66.1% in 2011, $p < 0.001$) and in the proportion of

patients admitted to the THC of Belo Horizonte (from 47.0% to 69.6%, p < 0.001).

Comparing the group of patients whose hospitalizations contemplated ICU stay with that whose hospitalizations did not contemplate ICU stay, higher mortality was observed in the former in 2009 (19.7% *versus* 8.8%, p < 0.001) and in 2010 (12.6% *versus* 7.6%, p < 0.001), but not in 2011 (7.8% *versus* 5.7%, p = 0.08). Analyzing separately those patients who stayed at the ICU, a statistically significant reduction in the mean hospital length of stay was observed, from 14.4±14.4 days in 2009 to 12.7±10.1 days in 2011 (p = 0.022), as well as an even more expressive reduction in mortality over the years than that of the entire sample, from 19.7% in 2009 to 12.6% in 2010 and 7.8% in 2011 (p < 0.001).

Discussion

The creation of the AMI system of care has led to the reorganization of the care provided to patients suspected of having ACS in the city of Belo Horizonte. This system included training and motivating the PCU teams, in addition to a higher integration between the services, enabling access to catheterization laboratories and beds in the ICU and THC. Data from the HIS showed a reduction in the AMI in-hospital mortality based on the establishment of that system of care with rates lower than those observed in the major Brazilian capitals.

Previous studies have shown that the high in-hospital mortality due to AMI in the Brazilian public health care system is associated with difficulties to access and low use of the treatment recommended for AMI, such as reperfusion therapy, drugs and ICU facilities[5]. Thus, Evangelista et al[25], studying SUS patients diagnosed with AMI in the city of Belo Horizonte in 2002 and 2003, have reported that only 33% of them had been admitted to the ICU during their hospitalization. In addition, having been admitted to a public hospital (as opposed to hospitals of the private health care system) was an independent factor of poor prognosis. A study carried out in Feira de Santana, state of Bahia, has reported a 19.5% mortality in AMI patients admitted to a public hospital of that city, four times greater than that found in patients admitted to three private hospitals in that same city (4.8%, p = 0.001)[26]. Among the patients admitted to the public hospital, the poor and illiterate ones predominated. These took longer to arrive at the hospital and to be medicated, and thus had greater clinical severity, characterized by a high prevalence of patients with Killip class II or over. Only 8% of the patients of the public hospital were admitted to the ICU, and 21% underwent reperfusion therapy; 94% of the patients of the private health care system were admitted to the ICU, thrombolytic agents being used in 79% of them. Beta-blockers, independent predictors of a better prognosis in this sample, have also been more frequently used in private hospitals[26].

Data regarding hospitalizations due to AMI in the city of Belo Horizonte in the period studied showed a tendency towards greater access of the population to high-complexity treatment after the implantation of the AMI system of care. That tendency can be inferred based on indirect data, such as the increase in the mean cost of hospitalization, which is primarily due to the greater access to tertiary hospitals, and, thus, to ICU beds. The greater access to high-complexity treatment is demonstrated by direct data, with a statistically significant increase in the AHAs to that type of hospitals and in the percentage of ICU cost per day. By ensuring a greater access to those resources, the possibility of performing complementary tests of fundamental importance in the management of the acute phase of ACS, such as echocardiography, treadmill test and nuclear medicine tests, is increased. In addition, the access to cardiac catheterization and PCI, which have impact on in-hospital and late adverse events, is increased[27-32].

Furthermore, the implementation of clinical protocols on the management of AMI, based on scientific evidence, is related to an improvement in the indicators of morbidity and mortality[33,34]. The Clinical Protocol on ACS of the Health Department of the State of Minas Gerais[22] was developed with the participation of professionals of the HC/UFMG, also involved with the establishment of the AMI System of Care in the City of Belo Horizonte and the training of the emergency. Knowing the local conditions is essential for properly applying the international guidelines. Thus, when elaborating the flowchart, we chose to recommend administering the thrombolytic agent at the ECU to patients with chest pain for less than 3 hours, because the shorter the ischemia duration, the more effective the thrombolytic therapy, and primary PCI would benefit those patients only if their referral occurred within the first 60 minutes[35,36], which cannot be currently accomplished within the transference system of the city of Belo Horizonte. The target delay time of that system is of up to 120 minutes, and the maximum target door-to-balloon time at the hospital with catheterization laboratory is 90 minutes[11,35,36]. It is worth emphasizing the option of direct case discussion, involving physicians at ECUs and general hospitals and specialists at CCUs, providing greater safety to the assistant physician and qualifying referrals referrals.

The implementation of the tele-electrocardiology system is an important component of the AMI System of Care in the City of Belo Horizonte, because it more quickly directs the transference of patients diagnosed with ACS with ST-segment elevation to the CCU. There is evidence of reduction in the door-to-balloon time and mortality with the use of pre-hospital ECG as component of the AMI system of care.

The results of the present study suggest that the establishment of the AMI system of care had a positive impact on the overall AMI in-hospital mortality after 2009. However, there are limitations regarding that analysis. This was an observational study, using secondary data derived from the AHAs issued in the period studied and dependent on data accuracy, from the primary care network to the in-hospital information flow. Additionally, only one of the clinical SUS procedures was selected; there were at least two more clinical procedures, in Additionally to the codes related to the interventions (percutaneous and surgical), which were not selected because of the information bias that could be generated. As an example, we can cite with ACS who ended up undergoing coronary angioplasty: in that case, with the change in the procedure, the patient will be in the system only among the cases of angioplasty and no longer among

Table 1 – Number of hospitalizations due to AMI, demographic variables and indicators related to access to treatment of AMI in the city of Belo Horizonte, from 2009 to 2011

Indicator	2009	2010	2011	p-value
Number of hospitalizations	1242	1113	1358	NA
Gender (% male)	63.3	63.9	62.0	0.609
Age (mean ± SD)	60.7 ± 13.0	60.4 ± 12.9	60.2 ± 13.0	0.528
Length of stay (days; mean ± SD)	12.9 ± 11.8	12.3 ± 9.9	12.5 ± 10.9	0.186
Mean hospitalization cost (R$; mean ± SD)	2480 ± 4054	2569 ± 3222	3501 ± 3202	< 0.001
Hospitalizations including ICU stay (n / %)	402/32.4	453/40.7	898/66.1	< 0.001
Proportion of AMI admitted to tertiary hospitals (%)	584/47.0	641/57.6	945/69.6	< 0.001
AMI in-hospital mortality (n/%)	153/12.3	107/9.6	96/7.1	< 0.001

SD: standard deviation; ICU: intensive care unit; AMI: acute myocardial infarction; NA: not assessed.

those with AMI. Angioplasty, however, could not be used in this analysis because it also encompasses outpatient elective procedures.

Another limitation is the fact that this study assessed only in-hospital mortality. Some patients with AMI die before hospital admission. Assessing out-of-hospital mortality is extremely important, because it also reflects access to treatment. Difficulties of access tend to increase the time to admission, decreasing the in-hospital lethality expected and increasing the out-of-hospital mortality.

However, despite those limitations, the missed data might relate to the subgroup of patients who benefited most from the network and access to high-complexity interventions, suggesting that the benefit might be even greater than that recorded. The mortality rates by the end of the establishment of the AMI system of care are lower than the mean reported in a study on the Brazilian reality[26] and those obtained directly from the HIS/Datasus.

Experiences on the organization of AMI care in other Brazilian cities have been reported[38,39]. All of them have been based, at least partially, on the observation that the organization of AMI management systems in other countries can significantly reduce mortality and morbidity due to AMI[40]. The importance of organizing the AMI care has been recognized by the Brazilian Ministry of Health, with the enactment, in December 2011, of an ordinance that regulates the implementation of AMI systems of care in Brazil, aiming at reducing the AMI mortality in the entire country. Reporting the experience in the city of Belo Horizonte is important to support the debate on such actions that can effectively reduce the burden of AMI in Brazil.

Author contributions

Conception and design of the research: Marcolino MS, Brant LCC, Araujo JG, Castro LRA, Lodi-Junqueira L, Ribeiro AL; Acquisition of data, Analysis and interpretation of the data and Critical revision of the manuscript for intellectual content: Marcolino MS, Brant LCC, Araujo JG, Nascimento BR, Castro LRA, Martins P, Lodi-Junqueira L, Ribeiro AL; Statistical analysis: Marcolino MS, Nascimento BR, Ribeiro AL; Obtaining funding: Marcolino MS, Brant LCC, Lodi-Junqueira L, Ribeiro AL; Writing of the manuscript: Marcolino MS, Brant LCC, Araujo JG, Nascimento BR, Castro LRA, Lodi-Junqueira L, Ribeiro AL.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any post-graduation program.

Original Article

Erratum

The article abstract Implementation of the Myocardial Infarction System of Care in City of Belo Horizonte, Brazil, published by Arquivos Brasileiros de Cardiologia in ahead of print, had the following change:

Abstract

Background: The creation of an acute myocardial infarction (AMI) system of care aims to optimize the management of patients from early diagnosis to proper and timely treatment.
Objective: To assess the establishment of an AMI System of Care in the City of Belo Horizonte, state of Minas Gerais, and its impact on AMI in-hospital mortality.
Methods: The AMI system of care was established in the city of Belo Horizonte between 2010 and 2011, aiming at increasing the access of patients of the public health system to the treatment recommended by the existing guidelines. The teams at the emergency care units were trained, and the tele-electrocardiography system was implemented in those units. The primary outcomes of this retrospective observational study were the number of admissions and AMI in-hospital mortality, from 2009 to 2011.
Results: During the study period, 294 professionals were trained and 563 electrocardiograms (ECGs) transmitted from emergency care units to coronary care units. A significant reduction was observed in the in-hospital mortality rate (12.3% in 2009 versus 7.1% in 2011, $p < 0.001$), while the number of admissions due to AMI remained stable. The mean cost of admission increased (mean R$ 2,480.00 versus R$ 3,501.00; $p < 0.001$), the proportion of admissions including intensive care unit stay increased (32.4% in 2009 versus 66.1% in 2011; $p < 0.001$), and the number of patients admitted to tertiary hospitals increased (47.0% versus 69.6%; $p < 0.001$).
Conclusion: The establishment of the AMI system of care improved the access of the population to proper treatment, thus reducing AMI in-hospital mortality. (Arq Bras Cardiol. 2013;100(4):307-314)
Keywords: Myocardial infarction / mortality; Myocardial infarction / therapy; Emergency Medical Services; Intensive Care Units.

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