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Implementing telemedicine in the initial care for ST-segment elevation myocardial infarction

Implementação da telemedicina no atendimento inicial do infarto agudo do miocárdio com supradesnívelamento do segmento ST

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DOI: 10.31160/JOTCI2018;26(1)A0014

ABSTRACT – Background: In ST-segment elevation myocardial infarction, the need for early recanalization of the culprit artery, associated to the difficult access of the general population to medical services that provide such treatment, contribute to increased mortality in such patients. This is the rationale for implementing the LATIN project, acronym for Latin America Telemedicine Infarct Network, in areas characterized by high demographic density and difficult access to healthcare services. The objective of the present study was to analyze the first year results of this project. **Methods:** The sample included six centers with telemedicine systems participating in the LATIN registry. In cases of acute myocardial infarction, the electrocardiogram and clinical summary were sent to the mobile phones of the interventional cardiologists at the reference hospital. Clinical and angiographic characteristics, intervals between care delivered and hospital outcomes were analyzed. **Results:** From June 2014 to June 2015, a total of 125 patients were enrolled, mean age of 58.3±11.1 years, 66.4% males, 30.4% suffering from diabetes mellitus and 28.8% smokers. A total of 85 primary percutaneous coronary interventions were performed with a mean door-to-balloon time of 46.4±25.0 minutes. The pharmaco-invasive strategy was adopted in 20.0% of patients. In-hospital mortality was 5.6%. **Conclusions:** The telemedicine system was a valuable partner in early diagnosis and rapid initiation of the gold standard treatment for acute myocardial infarction in the region analyzed, with possible impact in survival, cost reduction and morbimortality.

Keywords: Myocardial infarction; Telemedicine; Angioplasty; Time-to-treatment

RESUMO – Introdução: No infarto agudo do miocárdio com supradesnívelamento do segmento ST, a necessidade de recanalização precoce da artéria culpada, associada às dificuldades de acesso da população em geral aos serviços médicos que realizam esta modalidade de tratamento, contribui para o aumento da mortalidade nesse perfil de paciente. Diante do exposto, encontra-se o racional de implementação do projeto denominado LATIN, acrônimo para *Latin America Telemedicine Infarct Network*, em áreas caracterizadas por concentração demográfica densa e dificuldades de acesso à saúde. O objetivo do presente estudo foi analisar os resultados do primeiro ano deste projeto. **Métodos:** A amostra compreendeu seis centros dotados de telemedicina participantes do registro LATIN. Nos casos de infarto agudo do miocárdio, eletrocardiograma e resumo clínico eram encaminhados por mensagem para os celulares dos cardiologistas intervencionistas do hospital de referência. Foram analisadas as características clínicas, angiográficas, os intervalos de atendimento e os desfechos hospitalares. **Resultados:** De junho de 2014 a junho de 2015, foram incluídos 125 pacientes, com média de idade de 58,3±11,1 anos, 66,4% do sexo masculino, 30,4% portadores de diabetes melito e 28,8% tabagistas. Foram realizadas 85 intervenções coronárias percutâneas primárias, com tempo porta-balão médio de 46,4±25,0 minutos. A estratégia fármaco-invasiva foi realizada em 20,0% dos pacientes. A mortalidade hospitalar foi de 5,6%. **Conclusões:** O sistema de telemedicina foi um aliado valioso no diagnóstico precoce e na rápida instituição do padrão-ouro de tratamento do infarto agudo do miocárdio na região analisada, com possível impacto na sobrevida, na redução dos custos e na morbimortalidade.

Palavras-chave: Infarto do miocárdio; Telemedicina; Angioplastia; Tempo para o tratamento

How to cite this article:

Matsuda CN, Cade JR, Janella BL, Pazolini VA, Cintra GF, Bourget M, et al. Implementing telemedicine in the initial care for ST-segment elevation myocardial infarction. J Transcat Interv. 2018;26(1):eA0014. [https://doi.org/10.31160/JOTCI2018;26\(1\)A0014](https://doi.org/10.31160/JOTCI2018;26(1)A0014)

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Submitted on:

Dec 7, 2017

Accepted on:

Aug 29, 2018

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INTRODUCTION

In the United States, cardiovascular disease is estimated to kill 2,160 people per day. Among the deaths due to acute coronary syndrome, approximately 70% of them occur outside the hospital environment, resulting in a serious health problem.^{1,2} Despite the considerable progress in the treatment of ST-segment elevation myocardial infarction (STEMI) and ischemic coronary diseases in the last decades, with a significant reduction in mortality rates,^{3,4} there are still areas lacking in adequate health care services, such as rural areas and working class suburbs of large urban centers, where these benefits are not achieved.^{5,6} Therefore, lower mortality rates from STEMI are more pronounced in developed countries, among the population with higher schooling and income, especially due to timely access to adequate diagnosis and treatment, myocardial reperfusion by primary percutaneous coronary intervention (PCI) or fibrinolysis, access to dual antiplatelet therapy and hospitalization in coronary units.⁷⁻⁹

In Brazil, cardiovascular diseases are the leading cause of proportional mortality, accounting for 29% of deaths in 2010, which translates to approximately 53.8 deaths per 100 thousand inhabitants, greatly affecting the most productive age group in the country (30 to 69 years).¹⁰⁻¹² It is also estimated that ischemic heart disease accounted for 83 thousand deaths in 2014, 46.27% of which in the Southeast Region, ranking STEMI as the second most frequent cause of death, with high in-hospital mortality rates in the public health system, corresponding on average to 16.2% in 2000, 16.1% in 2005, and 15.3% in 2010.¹³ These statistics are attributed to difficulties in early diagnosis, and lack of patient access to myocardial reperfusion, intensive care and/or coronary care units, and the recommended therapeutic measures.¹⁴

The pathophysiological mechanism of STEMI is thrombus occlusion of one of the coronary arteries, with progressive functional loss of myocytes in the occluded artery-related topography. The mortality risk in the first year increases by 7.5% every 30 minutes of delayed recanalization of the vessel.⁸ Therefore, early reperfusion is the primary goal in the treatment of STEMI, which resulted in the current target of 60 minutes between the arrival of the patient at the hospital and the opening of the culprit artery.⁹ For this reason, several efforts are underway to triage, diagnose and transfer these patients to hospitals that have an interventional cardiology service with professionals experienced in implementing primary PCI.⁶

Among these measures, a strategy for optimizing care for STEMI patient is implemented in places with limited resources, using 12-lead ECGs, connected via *internet* to a central office, where trained physicians analyze the ECG for an earlier diagnosis of STEMI, and direct the removal of these patients to a hospital with a catheterization laboratory (cath lab).

Mehta et al. compared the implementation of this strategy, called *Latin America Telemedicine Infarct Network* (LATIN), in Colombia, observing a significant reduction of disparities in STEMI care between developed and developing countries. This finding is directly associated with the reduction in the time interval to perform and adequately interpret the ECG, with an early referral to primary PCI or thrombolysis.¹⁵ In Brazil, Solla et al. reported the first experience with this strategy, proving it to be feasible and with good outcomes, comparable to those in developed countries.¹⁶⁻¹⁸

Difficulties faced by the population in accessing tertiary care facilities with primary PCI or healthcare services capable of diagnosing STEMI, associated to the remoteness of the hospital *Casa de Saúde Santa Marcelina* (CSSM) location, were the rationale for implementing a LATIN pilot project on the outskirts of the eastern part of the city of São Paulo (SP), encompassing more than 5 million inhabitants.

The primary objective of the present study was to describe the implementation of the project, the flowchart for the removal of the STEMI patient, and the analysis of the first 125 patients after the first year of its opening. As a secondary objective, we analyzed the map of the eastern zone of São Paulo, the distance traveled to the CSSM, as well as the transport time from the primary service units to the CSSM, the door-to-balloon time, the first-medical-contact-to-balloon time, the angiographic outcomes, and the in-hospital clinical outcomes.

METHODS

This was a descriptive study, with retrospective implementation and flowchart data collection of the LATIN-CSSM project (<https://santamarcelina.org/hospital/telemedicina>), from June 2014 to June 2015. The primary care units located on the outskirts were called spokes, and the high-complexity central hospital (CSSM) was called hub. The spoke-hub transfer time and the hub-door-to-balloon time, as well as the in-hospital outcomes, were analyzed in terms of major adverse cardiac and cerebrovascular events. This study was approved by the Ethics and Research Committee of Hospital Santa Marcelina (CAAE: 67353517.7.0000.0066).

Implementation of the program

The program involves a trained multidisciplinary team, in the units participating in the project (spokes), equipped with 12-lead ECG devices connected to a telemedicine center. The program steps includes the patient's reception (immediate triage), and the professionals who perform the 12-lead ECG and send it online to the team of trained physicians at International Telemedical Systems (ITMS) located in Uberlândia (MG), Brazil.

Patients diagnosed with STEMI receive, unless contraindicated, 300mg of aspirin and 600mg of clopidogrel,

as well as coronary vasodilators (intravenous nitroglycerin) and, if necessary, analgesia with opioids and oxygen.

The patients are transported immediately, by an ambulance with a physician on board, to the cath lab at the CSSM. In the case of STEMI, the telemedicine company itself sends a cellphone message to the interventional cardiologist on call, communicating the diagnosis, and by email, a brief clinical summary and the ECG interpretation. Figure 1 shows the spoke activation flowchart, with the interface among ITMS, the transport team and the cath lab team, in case of a STEMI diagnosis.

Mapping of the spokes

At the time of this study, there were six centers equipped with 12-lead ECG devices (Table 1), connected to the telemedicine system, trained in chest pain patient care, with immediate triage, and electrocardiographic analysis and interpretation in less than 10 minutes. The centers that deliver care to patients are trained by the LATIN medical team, and monthly meetings are conducted to evaluate the program and minimize possible doubts about the project. Figure 2 shows, in São Paulo map, the distances between the spokes and the CSSM.

Figure 1. Activation flowchart of the Latin America Telemedicine Infarct Network (LATIN). The electrocardiogram is interpreted by the International Telemedical Systems (ITMS), which communicates it to the health center where the patient is (spoke), to the transport team, and to the Interventional Cardiology team (hub). Mehta procedure: the patient is admitted directly to the cath lab, without passing through the emergency room.

Table 1. Participating centers and mean distance to tertiary care service (in kilometers)

Medical centers (spokes)	Kilometers
Pronto-Socorro Municipal Júlio Tupy (spoke 1)	10.0
Hospital Municipal Cidade Tiradentes (spoke 2)	12.5
AMA Santa Marcelina (spoke 3)	0.6
Hospital Geral – Unidade Itaim Paulista (spoke 4)	15.0
Pronto Atendimento Dr. Atualpa Girão Rabelo (spoke 5)	12.0
Hospital Geral de Itaquaquecetuba (spoke 6)	20.8
Mean distance between spokes and Casa de Saúde Santa Marcelina (mean±standard deviation)	11.8±6.6

AMA: Outpatient Clinic.

Figure 2. Map of the Eastern zone of São Paulo with the centers participating (spokes) and their geographic position in relation to the hub. Source <https://www.google.com.br/maps>

Statistical analysis

Categorical variables were expressed as absolute numbers and percentages. Continuous variables were expressed as mean $\pm$ standard deviation or interquartile range, depending on the type of distribution. We used the Shapiro-Wilks test to evaluate the normal distribution. A p-value of <0.05 was considered significant, calculated by the statistical software R (R Development Core Team 2008).

RESULTS

The program started in June 2014. A total of 22,177 ECGs were generated by June 2015, all of which were analyzed by ITMS. The diagnosis of STEMI was confirmed in 125 (0.56%) patients, with mean age of 58.3 ± 11.1 years, and 66.4% of males. Diabetes mellitus was present in 30.4% of patients, hypertension in 60.0%, and active smoking in 28.8%. There were 25 (20.0%) cases in which thrombolytic therapy was indicated due to the unavailability of an ambulance to transport the patients to the hub, and coronary angiography was scheduled later. Of the universe of patients with thrombolysis, ten were excluded due to lack of data on health care indicators. The mean spoke-needle time was 71.0 ± 48.0 (16-207) minutes.

In eight (6.4%) patients, the case was discussed with the interventional cardiology team, and an elective coronary angiography was the procedure chosen due to the diagnosis of myocardial infarction (more than 12 hours after the onset of symptoms), without criteria for performing an emergency procedure. Exclusively medical therapy was indicated in seven (5.6%) patients. Surgical myocardial revascularization was indicated in nine (7.2%) patients, due to multivessel coronary disease, without refractory ischemia, at the time of coronary angiography (Figure 3).

Figure 3. Sample universe. ECG: electrocardiogram; STEMI: ST-segment elevation myocardial infarction; CA: coronary angiography; PTA: percutaneous transluminal angioplasty; CABG: coronary artery bypass graft.

In-hospital mortality was 5.6% ($n=7$), four of which were due to cardiac causes (one cardiogenic shock, two sudden deaths 12 hours after primary PCI, and one recurrent myocardial infarction). Non-cardiovascular causes included septic shock (one case), ovarian neoplasm (one case), and pulmonary thromboembolism (one case).

Primary PCI was performed in 85 (68.0%) patients, with angiographic success in 96.5% of cases (Table 2). The

Table 2. Clinical, angiographic and primary percutaneous coronary intervention procedures characteristics

Variables	
Age, years	58.3 (± 11.3)
Male	51 (60.0)
Diabetes mellitus	26 (30.6)
Active smoking	30 (35.3)
Hypertension	55 (64.7)
Culprit coronary artery	
LAD	48 (56.5)
RCA	30 (35.3)
LCX	6 (7.0)
SVG	1 (1.2)
TIMI pre-PCI	
0	58 (68.2)
1	8 (9.4)
2	8 (9.4)
3	11 (13.0)
TIMI post-PCI	
2	3 (3.5)
3	82 (96.5)
Radial approach	34 (40.0)
Femoral approach	51 (60.0)
Angiographic success	82 (96.5)

Results expressed as mean $\pm$ standard deviation or n (%). LAD: left anterior descending artery; RCA: right coronary artery; LCX: left circumflex; SVG: saphenous vein graft bypass; TIMI: Thrombolysis in Myocardial Infarction; PCI: percutaneous coronary intervention.

mean time between identification of STEMI and transfer to the hub (spoke-hub) was 78.0 ± 38.0 (21-260) minutes. The mean time between arrival at the hub and coronary recanalization (door-to-balloon time) was 46.4 ± 25.0 minutes. The mean first-medical-contact-to-balloon time was 124.4 ± 39.8 minutes, and 44 patients (51.8%) had an interval of less than 120 minutes (Table 3).

Table 3. In-hospital adverse outcomes and spoke-hub and door-to-balloon times of patients submitted to primary percutaneous coronary intervention

Variables	
Mortality	6 (7.0)
Stroke	0 (0.0)
Spoke-Casa de Saúde Santa Marcelina time, minutes	78.0 ± 38.0
First medical contact-balloon, minutes	124.4 ± 39.8
Casa de Saúde Santa Marcelina door-to-balloon time, minutes	46.4 ± 25.0

Results expressed as n (%) or mean $\pm$ standard deviation.

DISCUSSION

The implementation of an agile chest pain patient care system with a 12-lead ECG performed in the first 10 minutes of admission, connected via internet to a center with trained physicians who evaluate the presence of ST-segment elevation, myocardial infarction, offers the possibility of an early diagnosis, an initial direction for immediate removal of the patient to of a referenced tertiary center equipped with a cath lab, or initiation a fibrinolytic therapy adequate to remote places without a full-time cardiologist.^{15,17,19}

Sejersten et al.²⁰ suggested that a telemedicine service can increase the number of STEMI diagnoses, enabling appropriate treatment of the patients, and reducing the discrepancies among the diverse realities of the different services.¹⁵ This is a positive aspect of public health care, with possible cost reduction, considering that early coronary reperfusion reduces the extent of myocardial damage, preserving the overall ventricular function — although a cost-effectiveness analysis was not in the scope of our study.

LATIN is a pioneering project in the city of São Paulo, and its main objective is to perform primary PCI, differing from the program of the *Universidade Federal de São Paulo* (UNIFESP), in which out-of-hospital thrombolysis is the main focus. The promising outcomes support the feasibility of both systems.²¹ Other determining factors for the success of the program, already contemplated by a guideline dedicated to the topic, are early diagnosis and immediate transportation to the referral hospital for interventional cardiology. In our series, a transfer delay (78.0 ± 38.0 minutes) was observed, and the difficulty to optimize immediate transport is the preponderant factor. It is speculated that the use of an exclusive ambulance for the transportation of these patients could reduce this interval, and currently, each center has one single ambulance for general use.

The mean first medical contact-to-balloon time exceeded the norm recommended by approximately 5 minutes, whereas patients undergoing thrombolysis in different spokes showed door-to-needle times that are in keeping with current recommendations. Regarding the door-to-balloon time in the hub, we observed a mean value of only 46.4 ± 25.0 minutes, probably because the interventional cardiologists received telephone confirmation of STEMI on the way, which possibly resulted in an earlier vessel opening and, consequently, a better prognosis.²²

The direct transportation of patients with pre-hospital diagnosis of STEMI to the cath lab, preceded by contact and activation of the team, a characteristic observed in the flowchart of the analyzed program, is an effective measure that increases the percentage of patients with door-to-balloon time lower than 60 minutes, which translates into higher final Thrombolysis in Myocardial Infarction (TIMI) grade 3 flow rates, improvement of myocardial reperfusion markers, shorter time to reperfusion, and, consequently, decreased mortality rate.²³⁻²⁵

All-cause mortality in the in-hospital phase of the full sample (125 patients) was 5.6%, which is impactful when compared to that found in previous records – about 15%. Mortality due to STEMI is consistent with previously published series, ranging from 7.0% to 18.0%, and lower than the mortality rate recorded in the Department of Information Technology of the Unified Health System (DATASUS) in 2010, which was 15.3%.⁸ We attributed the observed reduction in this important indicator to the use of the LATIN program.

CONCLUSION

We reported the first project implemented in the city of São Paulo involving medical centers equipped with a telemedicine system in health care sectors lacking in adequate cardiology services. In addition to offering early diagnosis, initial treatment and rapid transportation, we observed an adequate door-to-balloon time, with low in-hospital mortality.

The LATIN project enables health care in economically underprivileged areas, using an appropriate flowchart, with possible impact on cost reduction, morbidity reduction, and long-term survival increase.

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