

Original Article

Impact of the implementation of hospital work processes on reduced door-to-balloon time

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ABSTRACT

Introduction: The time interval between symptom onset and coronary artery reperfusion for ST-elevation myocardial infarction is directly related to patient morbidity and mortality. The guidelines stipulate that door-to-balloon time, *i.e.*, the time spent between hospital arrival and percutaneous coronary intervention (PCI), must not exceed 90 minutes. Few hospitals achieve this goal. Thus, the objective of the present study was to assess the efficacy of the implementation of hospital work processes with respect to reducing the door-to-balloon time.

Methods: Two hundred twenty-two consecutive patients who presented spontaneously at the hospital from February 2008 to July 2013 and who underwent primary PCI were included in the study. During this period, the following strategies were implemented in a hierarchical manner: systematic measurement of door-to-balloon time (Group A), universal communication code (Group B), patient screening (Group C), and emergency cardiologist (Group D).

Results: Each implemented strategy entailed a gradual decline in the median door-to-balloon time (Group A: 145 minutes; Group B: 114.5 minutes; Group C: 88 minutes, and Group D: 70 minutes; $p < 0.0001$) and an increase in the percentage of patients with door-to-balloon times below or equal to 90 minutes (Group A: 0%; Group B: 43.3%; Group C: 51.6%; Group D: 76.2%; $p < 0.0001$).

Conclusions: This study demonstrated the efficacy of the implemented strategies for reducing door-to-balloon time, with more than 75% of cases with this time below 90 minutes.

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Impacto da adoção de processos de trabalho hospitalares na redução do tempo porta-balão

RESUMO

Introdução: O tempo entre a instalação dos sintomas e a reperfusão do vaso responsável pelo infarto agudo do miocárdio com supradesnivelamento do segmento ST está diretamente relacionado à morbimortalidade do paciente. As diretrizes preconizam que o tempo dispendido entre a chegada ao hospital e a realização da intervenção coronária percutânea (ICP) seja de, no máximo, 90 minutos, denominado tempo porta-balão. Poucos hospitais atingem esta meta. Este estudo teve como objetivo avaliar a eficácia da implementação de processos de trabalho hospitalares para reduzir este tempo.

Métodos: Foram incluídos 222 pacientes consecutivos admitidos por procura espontânea entre fevereiro de 2008 e julho de 2013, tratados com ICP primária. Durante este tempo, foram adicionadas as seguintes estratégias, de forma hierarquizada: medição sistemática do tempo porta-balão (Grupo A), código de comunicação universal (Grupo B), triagem de pacientes (Grupo C), médico emergencista cardiologista (Grupo D).

Resultados: A cada estratégia adicionada, houve queda gradual da mediana do tempo porta-balão (Grupo A: 145 minutos; Grupo B: 114,5 minutos; Grupo C: 88 minutos e Grupo D: 70 minutos; $p < 0,0001$) e aumento do percentual de pacientes com tempo porta-balão menor ou igual a 90 minutos (Grupo A: 0%; Grupo B: 43,3%; Grupo C: 51,6%; Grupo D: 76,2%; $p < 0,0001$).

Conclusões: Este estudo comprovou a eficácia das estratégias instauradas para reduzir o tempo porta-balão, chegando a superar o valor de 75% dos casos com tempo porta-balão menor que 90 minutos.

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Palavras-chave:

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Introduction

ST-segment elevation myocardial infarction (STEMI) is the most critical presentation of acute coronary syndrome and, in most cases, is due to total occlusion of an artery by a thrombus formation on ruptured atherosclerotic plaques.

In recent decades, percutaneous coronary intervention (PCI) has become the gold standard treatment for STEMI patients.¹ In addition to reducing mortality, this method has also brought other advantages, such as quick restoration of coronary blood flow, access to the coronary anatomy, risk stratification, larger salvaged myocardium, and earlier hospital discharge.² It is also known that the time interval between symptom onset and primary PCI has a significant impact on patient morbidity and mortality.³⁻⁵

To achieve a higher benefit from PCI, the time spent between first patient contact with the hospital and artery reperfusion should be as short as possible. This intra-hospital time interval is called the door-to-balloon (D2B) time, and its maximum recommended duration is 90 min.^{6,7}

Considering the number of Interventional Cardiology services that perform PCI in Brazil, the number of national publications addressing the D2B time remains small. We sought to identify hospital work processes that could significantly contribute to a reduction of the D2B time and to identify changes in the experience of a reference service after the implementation of these measures.

Methods

The present work is a retrospective observational study that consecutively included all patients who presented spontaneously at the hospital between February 2008 and July 2013, with STEMI⁶ and underwent primary PCI. Patients transferred from other health care services were excluded, as were those who, by exception to the rule, received thrombolytic therapy in our hospital.

The service studied here was from a private hospital with 150 beds, pioneering in Cardiology, in the city of Belo Horizonte, Minas Gerais State, Brazil. The Service of Interventional Cardiology has existed since 1975 and has been routinely performing primary PCI on STEMI patients since the year of 2001. At the time of the study, approximately 50 primary PCI were being performed per year. The emergency care unit was located in the first floor, 50 m from the cath lab.

The implemented processes were in agreement with the six strategies that Bradley et al. identified to be strongly associated with reduced D2B time.⁸ In summary, these strategies include obtaining an immediate electrocardiogram (ECG) in the emergency department, emergency department physician activation of the catheterization laboratory, having an attending cardiologist always on site, and having staff in the emergency department and the catheterization laboratory use real-time data feedback.

During the studied period, the door attendant of the emergency department recorded the name and time of arrival of all patients who entered the emergency area, independent of their complaint and before their medical record was established. The interventional cardiology team, which was on call 24 hours per day, 7 days per week, was activated by direct contact via cell phone and, once in the intervention room, recorded the time at which the 0.014" guide wire had crossed the occlusion. This time interval between the patient entering the emergency department and the guide wire crossing the affected artery was termed the D2B time.

As of the beginning of February 2008, this time measurement was performed systematically. From that date on, three other strategies were implemented at different times. There was no base planning of the changes. During the course of time after the beginning of measurements, we identified the stages of medical assistance with the highest potential for improvement and implemented each of the strategies described below until we achieved a satisfactory D2B time.

First, in August 2008, we implemented a standardized communication code to ease communication between the different hospital sectors, aiming to prioritize clinical tasks and bureaucracy in the process of medical assistance (receptionists, nurses, anesthetists, and interventional cardiologists). The second measure, implemented in March 2009, was the formalization and standardization of patient screening in the emergency room, during which a nurse prioritized cases possibly related to ACS. From this moment on, we focused on performing an ECG and delivering it to the physician on duty within 10 min. In July 2010, the third and final implemented strategy was to hire emergency cardiologists who were on call in the emergency department 24 hours per day to see the screened cases under suspicion of ACS.

We divided the patient sample into four groups (A through D). Each group represents patients seen in a different time period: the population of the beginning of D2B time measurement (Group A); after implementation of the communication code (Group B); after the implementation of screening (Group C); and, finally, after the implementation of an emergency cardiologist (Group D). Clinical and angiographic data were collected from all patients, as was the D2B time, and a digital database was established.

All patients received treatment in the emergency room, following a protocol based on current guidelines, as well as the treatment strategy adopted by the interventional cardiologist in the cath lab.⁶ This study has been approved by the ethics committee of the institution and was in agreement with the Declaration of Helsinki⁹ and Resolution 466/2012 of the National Health Council.¹⁰

Statistical analysis

Qualitative categorical and ordinal variables were described as absolute frequencies and percentages. Normally distributed quantitative variables (assessed with the Shapiro-Wilk's test) were described as the mean \pm standard deviation. In the absence of normal distribution, the median [Q1; Q3] was used. Groups were compared regarding qualitative variables with Pearson's asymptotic Chi-square test (when 20% of the expected value was between 1 and 5), Pearson's exact Chi-square test (when more than 20% of the expected value was between 1 and 5), and Monte Carlo simulations (when the exact test did not apply). Normally distributed quantitative variables (assessed with the Shapiro-Wilk test) were compared by analysis of variance (ANOVA) and least significant difference (LSD) in multiple pairwise comparisons to identify statistically significant differences. The Kruskal-Wallis test was used in the absence of normal distribution. The Mann-Whitney *U* test with Bonferroni correction was used for pairwise multiple comparisons (with a significance level of 0.0125). Statistical significance was established at 0.05, and analyses were performed with the Statistical Package for Social Science version 20.0 (SPSS Inc., Chicago, USA).

Results

The studied population consisted of 222 patients with a mean age of 63.5 \pm 13.7 years, among which 45.5% were \geq 65 years old, and 65.8% were men. The division of the sample into groups is shown in Table 1 and exhibits similarities regarding sociodemographic and clinical characteristics among patients. In the comparison of paired samples, individuals from Group C were significantly older than those from Groups B ($p = 0.001$) and D ($p = 0.02$).

The median D2B time was 80.5 [Q1:58.5 and Q3:126.0] minutes. A total of 123 (58.0%) patients were treated within a D2B time \leq 90 min. Table 2 shows the median value of D2B time according to group. There were significant differences between Groups A and C ($p < 0.0001$), A

and D ($p < 0.0001$), B and D ($p = 0.002$), and C and D ($p = 0.009$). There were no statistically significant differences between Groups A and B ($p = 0.195$) and B and C ($p = 0.083$) (Figure 1).

The median D2B time decreased with the evolution of the implemented measures and achieved 70 min in the last patient group. Paired group analysis showed that the implementation of a new measure alone was not sufficient to significantly change the D2B time (as between Groups A and B and Groups B and C) but provided benefits when taken together (such as from Groups A to C and from Groups B to D). However, the implementation of an emergency cardiologist in itself (from Groups C to D) significantly changed the median, with 76.2% of the cases with D2B times ≤ 90 min in Group D (Figure 2).

Discussion

In the present case series, we show that systematizing hospital work processes, implemented in a hierarchical manner, comprises a viable and efficient tool to reduce D2B time among admitted patients with a diagnosis of STEMI. Even though the literature exhibits conflicting results regarding the relationship between D2B time and

in-hospital or late mortality,¹¹⁻¹⁴ it is, nevertheless, an important quality indicator for myocardial infarction care and is widely supported by the current guidelines.^{6,7} In fact, the real impact of reduced D2B time on patient prognosis is directly correlated with the interval it represents within total ischemic time, beginning at symptom onset.¹⁵

In 2006, the American College of Cardiology (ACC) presented the Door-to-Balloon Alliance to promote D2B time reduction measures at a national scale, aiming at a minimum 75% of non-transferred cases to have D2B times ≤ 90 min.¹⁶ Starting at a percentage of approximately 50%, in 2008, 75% of the cases already exhibited D2B times ≤ 90 min.¹⁷ Between 2005 and 2010, the median North-American D2B time was reduced from 96 min to 64 min.¹⁸ Another relevant measure was the financial incentive for hospitals with the best indicators. For specialized cardiology hospitals, D2B time was used to assess the quality of treatment of STEMI patients. Notably, hospitals treating patients from the American health care system Medicare that do not achieve a D2B time below 90 min are penalized 2% of the reimbursement of each and any service that is covered by this system, thus potentially causing financial losses.¹⁹

This rule has been questioned in the United States for three reasons: it uses a single quality marker, which is insufficient for broad

Table 1
Clinical variables

Variables	Group A (n = 17)	Group B (n = 30)	Group C (n = 62)	Group D (n = 113)	p value
Age, years	64.9 ± 13.8	57.8 ± 12.8	67.6 ± 14.5	62.6 ± 12.9	0.009*
Age ≥ 65 years, n (%)	10 (58.8)	7 (23.3)	34 (54.8)	50 (44.2)	0.02†
Male sex, n (%)	11 (64.7)	23 (76.7)	38 (61.3)	74 (65.5)	0.54†
Hypertension, n (%)	10 (58.8)	22 (73.3)	40 (64.5)	70 (61.9)	0.67†
Diabetes mellitus, n (%)	1 (5.9)	11 (36.7)	16 (25.8)	21 (18.6)	0.05‡
On metformin	1 (5.9)	7 (23.3)	8 (13.1)	11 (9.8)	0.19‡
On insulin	0 (0)	1 (3.3)	4 (6.6)	7 (6.3)	0.73‡
Hypercholesterolemia, n (%)	11 (64.7)	15 (50.0)	32 (51.6)	51 (45.1)	0.47†
Smoking, n (%)					0.79†
Active	6 (35.3)	9 (30.0)	15 (24.2)	40 (35.4)	
Ex-smoker	3 (17.6)	4 (13.3)	8 (12.9)	16 (14.2)	
Creatinine clearance < 60, n (%)	1 (5.9)	4 (13.3)	7 (11.3)	6 (5.3)	0.37‡
Treated vessel, n (%)					0.003§
RCA	3 (17.6)	7 (23.3)	26 (41.9)	37 (32.7)	
LCx	2 (11.8)	5 (16.7)	10 (16.1)	11 (9.7)	
LAD	8 (47.1)	16 (53.3)	24 (38.7)	63 (55.8)	
Diagonal branch	1 (5.9)	0 (0.0)	0 (0.0)	0 (0.0)	
Obtuse marginal branch	2 (11.8)	2 (6.7)	0 (0.0)	2 (1.8)	
SVG to LAD	0 (0.0)	0 (0.0)	1 (1.6)	0 (0.0)	
SVG to obtuse marginal branch	0 (0.0)	0 (0.0)	1 (1.6)	0 (0.0)	
Left main coronary artery	1 (5.9)	0 (0.0)	0 (0.0)	0 (0.0)	
Final TIMI flow, n (%)					0.11†
0	4 (23.5)	7 (23.3)	7 (11.3)	7 (6.2)	
I	1 (5.9)	3 (10.0)	5 (8.1)	2 (1.8)	
II	2 (11.8)	3 (10.0)	8 (12.9)	8 (7.1)	
III	10 (58.8)	17 (56.7)	42 (67.7)	96 (84.9)	
KILLIP class, n (%)					0.41§
Unknown	4 (23.5)	3 (10)	1 (1.6)	0 (0.0)	
I	11 (64.7)	21 (70.0)	46 (74.1)	84 (74.3)	
II	1 (5.9)	2 (6.7)	5 (8.0)	6 (5.3)	
III	1 (5.9)	0 (0.0)	0 (0.0)	8 (7.1)	
IV	0 (0.0)	4 (13.3)	10 (16.1)	15 (13.3)	

* Analysis of variance; † Pearson's asymptotic Chi-square test; ‡ Pearson's exact Chi-square test; § Monte Carlo Pearson's exact Chi-square test. RCA: right coronary artery; LCx: left circumflex artery; LAD: left anterior descending artery; SVG: saphenous vein graft; TIMI: Thrombolysis in Myocardial Infarction.

Table 2
Comparison of time variables among groups

Variables	Group A	Group B	Group C	Group D	p value
D2B time, minutes	145 [134; 157]	114.5 [64.3; 187.5]	88 [58.5; 125.5]	70 [55; 90]	< 0.0001*
D2B time, minutes					< 0.0001†
≤ 90, n (%)	0 (0.0)	13 (43.3)	32 (51.6)	86 (76.2)	
> 90, n (%)	17 (100.0)	17 (56.7)	30 (48.4)	27 (23.8)	

* Kruskal-Wallis test; † Pearson's asymptotic chi-square test. D2B: door-to-balloon.

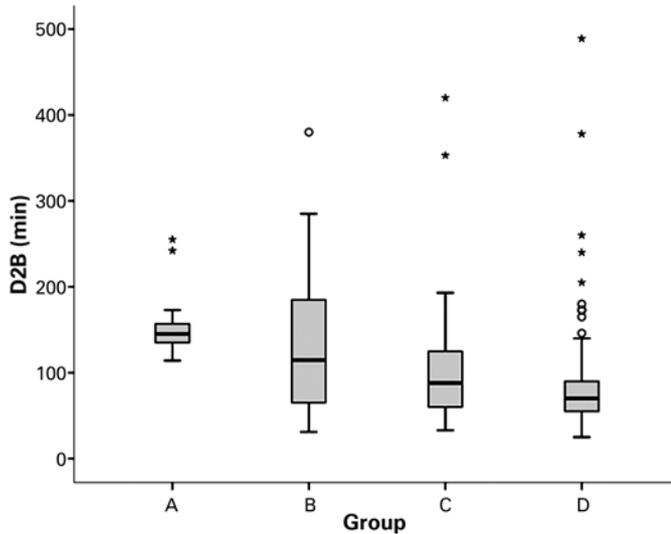


Figure 1. Box-and-whisker plot of door-to-balloon (D2B) times by group.

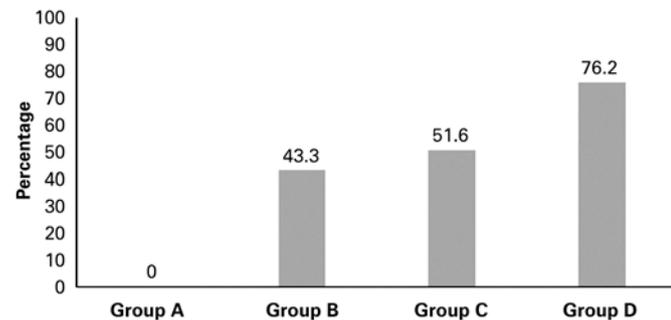


Figure 2. Patients with D2B times below 90 min, by group.

and detailed evaluation of the service; it stimulates early indications of coronarography, thus increasing the number of unnecessary or futile procedures, with 14% to 36% of patients diagnosed with STEMI and forwarded to intervention being reclassified as false-positives;²⁰ and, finally, it increases the number of underreported cases due to the abuse of Medicare quality report exclusion criteria, as suggested by the increase in excluded cases from 13.9% in 2005 to 36.7% in 2011.²¹ Even though this payment system based on treatment performance is subject to criticism, its implementation in the German health care system is under legislative discussion considering two variables: risk-adjusted mortality rate and D2B time.²²

Advancing technology and simplified telemedicine are useful assets in the attempt to improve the treatment of infarcted patients. The use of broadband digital communication by means of cell phones re-

duces D2B time, enabling both the discussion of ECG diagnosis and the activation of the interventional cardiology team. In a study from China, the implementation of a coordinated digital communications system increased the percentage of patients with D2B times < 90 min from 26.0% to 82.5% ($p < 0.001$) and reduced both costs and hospital stays.²³

In our study, the major problems related with D2B time included the delay between hospital arrival and first medical treatment, which was resolved with the full-time screening protocol; in-hospital communication and lack of priority, which were improved with the standardized code; and the diagnostic delay, which was counteracted by the presence of an emergency cardiologist.

Other factors that could influence D2B time are the patient socio-demographic profile, training of the treatment teams, the bureaucracy, patient transport, and the distance to the cath lab. The strategies to be implemented must aim at the time gaps of each service.

Limitations

The present study exhibits some biases, such as the fact that it is retrospective and unidirectional. Furthermore, the number of patients, especially in the first two groups, is small. This small sample size is due to ethic issues since, as soon as the D2B time exceeded the desired value, the next strategy was quickly implemented to increase efficiency. During the present study, partial time intervals were assessed during each stage of the treatment chain, as was the time between screening and delivery of the ECG to the doctor, the time of relocating the interventional cardiology team, and other variables. However, these important data were not included in the present analysis because of the difficulties regarding the implementation of efficient and standardized partial measurements.

Conclusions

The systematic implementation of hospital work processes is an efficient strategy to reduce door-to-balloon time, thus avoiding unnecessary delays caused by bureaucracy, delayed diagnosis, team activation, or even the treatment of acute myocardial infarction. Keeping the door-to-balloon time as low as possible is an everyday labor-intensive task. However, it is rewarding for patients and all teams involved.

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Conflicts of interest

The authors declare no conflicts of interest.

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