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Association of door-to-balloon time and clinical factors with hospital shifts

Associação entre o tempo porta-balão e fatores clínicos com turnos hospitalares

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ABSTRACT – Background: In ST-segment elevation myocardial infarction, the main therapy is early arterial reperfusion, performed by primary percutaneous coronary intervention. The recommended door-to-balloon time is <90 minutes. The objective of this study was to associate the door-to-balloon time and clinical factors with hospital shifts. **Methods:** This was a cross-sectional observational study, part of the *Catarina Heart Study*. We analyzed patients diagnosed with ST-segment elevation myocardial infarction in hospitals of the metropolitan area of Florianópolis, from 2016 to 2020. The qualitative variables were analyzed using the Chi-square test, and the quantitative variables were analyzed using the Student's *t* test and Mann-Whitney test. **Results:** A total of 318 patients were analyzed, with a mean age of 58.7±11.4 years, predominantly male (71.7%) and hypertensive (53.7%). The median door-to-balloon time was significantly lower in the group seen on weekdays compared to the group seen on weekends, respectively, 71.0 (51.0-126.0) minutes and 91.0 (71.0-123.0) minutes (*p*=0.028). There was no difference in the door-to-balloon time in the night shift and in off-hours. Individuals undergoing primary percutaneous coronary intervention during the night shift showed a non-significant tendency for higher mortality rates from any cause (1.9%) compared to those seen during the day shift (0.0%; *p*=0.057). **Conclusion:** Patients with ST-segment elevation myocardial infarction seen on weekdays have shorter door-to-balloon time.

Keywords: ST-segment elevation myocardial infarction; Angioplasty; Myocardial reperfusion

RESUMO – Introdução: No infarto agudo do miocárdio com supradesnivelamento do segmento ST, a terapêutica principal é a reperfusão arterial precoce, realizada por meio da intervenção coronária percutânea primária. Recomenda-se que o tempo porta-balão seja <90 minutos. O objetivo deste estudo foi associar o tempo porta-balão e os fatores clínicos com turnos hospitalares. **Métodos:** Estudo observacional transversal, aninhado ao *Catarina Heart Study*. Foram analisados pacientes com diagnóstico de infarto agudo do miocárdio com supradesnivelamento do segmento ST, em hospitais da Grande Florianópolis, de 2016 a 2020. As variáveis qualitativas foram analisadas pelo teste do qui-quadrado e as quantitativas pelo teste *t* de Student e pelo teste de Mann-Whitney. **Resultados:** Foram analisados 318 pacientes, com média de idade de 58,7±11,4 anos, predominância masculina (71,7%) e de hipertensos (53,7%). A mediana do tempo porta-balão foi significativamente menor no grupo atendido em dias úteis comparado ao atendido durante finais de semana, respectivamente, 71,0 (51,0-126,0) minutos e 91,0 (71,0-123,0) minutos (*p*=0,028). Não houve diferença no tempo porta-balão no período noturno e nas horas não úteis. Indivíduos submetidos à intervenção coronária percutânea primária durante o período noturno apresentaram tendência não significativa de maiores taxas de mortalidade por qualquer causa (1,9%) comparados aos atendidos no período diurno (0,0%; *p*=0,057). **Conclusões:** Pacientes com infarto agudo do miocárdio com supradesnivelamento do segmento ST atendidos em dias úteis apresentam menor tempo porta-balão.

Descritores: Infarto do miocárdio com supradesnível do segmento ST; Angioplastia; Reperfusion miocárdica

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INTRODUCTION

According to the American Heart Association (AHA), cardiovascular diseases (CVD) are the main causes of death in the world, accounting for 17.9 million deaths, with 43.8% of them due to acute coronary diseases. In the United States, CVD

account for one in three deaths, and rank first in mortality.¹ Nationwide, in 2017, the CVD mortality rate was approximately 27.3%, and the majority of deaths were due to ischemic heart diseases.²

Among the most frequent CVD is acute myocardial infarction (MI).³ The location of the obstruction, the duration of ischemia, and the extent of myocardial injury help determine the type of coronary syndrome suffered. In ST-segment elevation MI (STEMI), there is complete closure of the coronary artery, causing acute myocardial ischemia.^{4,5}

Coronary reperfusion is the main therapy for STEMI, performed through primary percutaneous coronary intervention (PCI) or intravenous fibrinolytic therapy.⁶ For hospital services with available primary PCI, this should be the method of choice for all patients whose onset of symptoms of ischemia was less than 12 hours before starting of the procedure.⁷ In addition, it is aimed and recommended that the door-to-balloon time be less than or equal to 90 minutes.^{5,8}

The reduction in door-to-balloon time is an important predictor of prognosis and mortality.⁵ A 60-minute delay in door-to-balloon time was associated with a 55% increase in one-year mortality.⁹ The literature is still divergent and scarce, and the data are inconsistent as to the influence of the day and the shift when the reperfusion procedure by primary PCI is conducted. Especially in Brazil, little has been reported on the subject. The assessment of door-to-balloon time in primary PCI performed on different days and shifts can contribute to evaluation of quality of hospital care, to improving treatment of patients with STEMI, and the consequent reduction in mortality and complications of the disease.

Considering this divergence, this study aimed to associate the door-to-balloon time and clinical factors with hospital shifts.

METHODS

This was a cross-sectional observational study, carried out through partial analysis of data from the cohort Catarina Heart Study. Patients of both sexes were evaluated, with the first MI event between July 2016 and June 2020, and treated at hospitals in the metropolitan area of Florianópolis (SC).

The inclusion criteria were age over 18 years; presence of chest pain suggestive of acute MI associated with electrocardiogram with new elevation of the ST-segment at the J point, in two contiguous leads ≥ 2.5 mm (0.25mV) in men under 40 years, ≥ 2 mm (0.2mV) in men over 40 years, or ≥ 1.5 mm (0.15mV) in women in leads V2 and V3 and/or >1 /mm (0.1mV) in other leads. The following patients were excluded: patients with previous acute MI, patients with an interval between the onset of symptoms and arrival at hospital longer than 12 hours, and patients with no ST-segment elevation.¹⁰

The main objective of this study was to analyze the association between door-to-balloon time and clinical factors with hospital shifts in post-infarction patients. The secondary objectives were to characterize the sociodemographic

and clinical aspects, as well as the adverse outcomes; to identify and compare door-to-balloon time among the groups seen in different hospital shifts; to identify the relation between door-to-balloon time in the groups attended in different hospital shifts, and the availability of an Interventional Cardiology Service in the period; to associate the door-to-balloon time in different hospital shifts with the clinical characteristics, and compare the 30-day clinical outcomes. The secondary outcomes were assessed using the Thrombolysis in Myocardial Infarction (TIMI) frame count, the SYNTAX score, and the left ventricular ejection fraction (LVEF). Differences in coronary flow after primary PCI were assessed using the Thrombolysis in Myocardial Infarction (TIMI) frame count; the difference in complexity of coronary lesions were assessed using the SYNTAX score, and the ventricular function after acute MI was assessed by means of LVEF with an echocardiogram performed during the event-related hospitalization.¹¹⁻¹³ A combined outcome is the occurrence of two or more clinical outcomes in 30 days (stroke, acute MI, unstable angina, stent thrombosis, in-stent restenosis, readmission, death due to cardiovascular causes or any cause).

For better characterization, the hospital shifts when the primary PCI was conducted were divided into working days (Monday to Friday), weekends (Saturday and Sunday), day shift (period between 8 am and 5 pm), night shift (period between 5 pm and 8 am), on-hours (day shifts on weekdays) and off-hours (night shifts and weekends). It is important to note that the Catarina Heart Study was carried out in hospitals with an on-call scheme at night shifts and on weekends.

The data were tabulated using the Windows Excel software and subsequently analyzed using the Statistical Package for the Social Sciences (SPSS) version 13.0 (SPSS Inc, Chicago, 2005). The qualitative variables were expressed as absolute and percentage numbers and assessed using the Chi-square test. The quantitative variables with normal distribution were expressed as mean $\pm$ standard deviation and evaluated by the Student's *t* test for independent samples. The quantitative variables with non-normal distribution were expressed as median and interquartile range, and assessed using the Mann-Whitney test. Normality was assessed using the Kolmogorov-Smirnov test. Significance was established at $p < 0.05$. A sample of 154 patients with a power of 90% and an α of 5% was calculated to find the difference of 14 minutes in door-to-balloon time between on- and off-hours.¹⁴

This study was submitted to and approved by the Research Ethics Committee of the *Instituto de Cardiologia de Santa Catarina*, under protocol CAAE 55450816.0.1001.0113, as provided by Resolution 466/12, of December 12, 2012, of the National Health Council. All patients received guidance and signed the Informed Consent Form.

RESULTS

In the period from 2016 to 2020, a total of 732 patients were included in the Catarina Heart Study, of which 318

had STEMI and were included in this assessment. Of these, the mean age of population was 58.7 ± 11.4 years, and there was a predominance of males (71.7%). Hypertensive patients accounted for more than half (53.7%) of study population. The door-to-balloon time found for the patients analyzed was 84.0 minutes (55.0 to 126.0). Data on the door-to-balloon time were available in 235 patients (73.9%), and in the other cases, there was no record of the balloon time. The other sociodemographic, clinical and adverse outcomes are shown in table 1.

The door-to-balloon time, according to the time when the primary PCI was performed, is described in table 2. Patients undergoing the procedure during the weekend had a longer door-to-balloon time than those who had it during working days: 91.0 (71.0 to 123.0) and 71.0 (51.0 to 126.0) minutes, respectively ($p=0.028$). There was no difference in door-to-balloon time when comparing day and night shifts or on- and off-hours.

There was no association between different hospital shifts and clinical characteristics, complexity of coronary lesions, coronary flow after primary PCI, or post-infarction LVEF. The data are shown, respectively, in tables 3 and 4.

When analyzing the door-to-balloon time with the 30-day outcomes (Table 5), a non-significant trend in all-cause mortality was observed in patients undergoing primary PCI at night shift (1.9%), compared to those seen during the day shift (0%; $p=0.057$). There was also a greater number of cases of readmission for any cause in 30 days, in patients seen during the day shift (9.1%), as compared to those undergoing the procedure during the night shift (2.9%) ($p=0.046$).

Table 1. Description of clinical, laboratory and socio-demographic parameters

Variable	
Male	228 (71.7)
Hypertension	169 (53.7)
Diabetes mellitus	64 (20.3)
Dyslipidemia	86 (27.4)
Family history	135 (42.9)
Prior stroke	4 (1.6)
PAOD	1 (0.4)
Former smoker	102 (32.5)
Smoking habit	119 (38.1)
Alcohol consumption	122 (38.4)
Age*	317 (58.7 ± 11.4)
LVEF*	257 (48.0 ± 11.6)
SYNTAX†	294 [14.5 (8.4-20.5)]
TIMI frame count†	223 [24.0 (16.0-34.0)]
Door-to-balloon time†	235 [84.0 (55.0-126.0)]

Results expressed as n (%), n (mean $\pm$ standard deviation) or n (median [interquartile range]).

PAOD: peripheral arterial obstructive disease; LVEF: left ventricular ejection fraction; TIMI: Thrombolysis in Myocardial Infarction.

Table 2. Door-to-balloon time in minutes in different different hospital shifts

Variable	n (%)	Door-to-balloon time Median (interquartile range)	p-value
Day of the week			
Working days	168 (71.5)	71.0 (51.0-126.0)	0.028
Weekend	67 (28.5)	91.0 (71.0-123.0)	
Hospital shift			
Day shift	150 (63.8)	81.0 (54.7-127.2)	0.787
Night shift	85 (36.2)	71.5 (52.5-122.7)	
Time period			
On-hours	103 (43.8)	76.5 (51.0-142.5)	0.183
Off-hours	132 (56.2)	83.5 (57.0-122.5)	

DISCUSSION

The sociodemographic and clinical aspects of this study showed a predominantly male population, with a mean age of 59 years and associated with hypertension, dyslipidemia, family history of acute MI and active smoking. These characteristics are in line with the European and national studies that had larger samples.¹⁵⁻¹⁸

The median door-to-balloon time observed in this study was within the 90 minutes recommended by international guidelines,⁵ with the exception of the procedures performed on weekends. Significant differences were observed in door-to-balloon time in primary PCI conducted during working days when compared to weekends, although there was no difference in door-to-balloon time when comparing day and night shifts or on-hours and off-hours. Most international and national studies do not differentiate between weekdays and weekends when primary PCI are performed, but only differentiate between on-hours and off-hours. Tang et al.¹⁹ demonstrated that patients seen on weekdays have shorter door-to-balloon time compared to those seen on weekends (84 and 109 minutes respectively).¹⁹ There are other data that confirm that the door-to-balloon time of individuals seen off-hours seems significantly longer than the door-to-balloon time of individuals seen on-hours.^{17,20} The difference can be explained mainly by two reasons: delay in making diagnosis of STEMI and, consequently, delay in referring the patient to the cath lab, and also the smaller number of employees available at the service during weekends.^{19,20} In addition, another reason for delay in treating patients undergoing a primary PCI performed off-hours can be the logistical difficulty in reaching the on-call interventional cardiology service staff.¹⁴ There are data, however, such as those reported by Ogita et al.,²¹ demonstrating the door-to-balloon times in off-hours and on-hours groups did not show significant differences. This finding may be explained by the fact that Japan has an active protocol for assisting patients undergoing primary PCI.²¹ Similar results were found in a Spanish study conducted at a cardiology reference center.²²

Table 3. Association between hospital shifts and clinical characteristics

Variable	Working days	Weekend	p-value	Day shift	Night shift	p-value	Working hours	Non-working hours	p-value
Hypertension	125 (53.9)	44 (53.0)	0.892	107 (53.8)	62 (53.4)	0.956	78 (55.3)	91 (52.3)	0.593
Diabetes mellitus	49 (21.1)	15 (18.1)	0.554	40 (20.1)	24 (20.7)	0.900	30 (21.3)	34 (19.5)	0.703
Dyslipidemia	67 (28.9)	19 (23.2)	0.319	58 (29.3)	28 (24.1)	0.323	45 (31.9)	41 (23.7)	0.104
Family history	97 (41.8)	38 (45.8)	0.530	86 (43.2)	49 (42.2)	0.866	60 (42.6)	75 (43.1)	0.922

Results expressed as n (%).

Table 4. Association between hospital shifts and secondary outcomes

Variable	Working days	Weekend	p-value	Day shift	Night shift	p-value	Working hours	Non-working hours	p-value
<i>TIMI frame count</i>	22.0 (14.0-34.0)	24.0 (16.0-34.0)	0.309	24.0 (16.0-32.5)	24.0 (14.0-37.5)	0.497	22.0 (14.0-32.0)	25.0 (16.0-34.9)	0.241
SYNTAX	14.0 (9.0-21.0)	14.20 (7.0-20.5)	0.890	14.0 (8.4-21.1)	13.5 (8.2-20.5)	0.671	14.8 (9.0-21.5)	13.8 (8.0-20.5)	0.505
LVEF	48.1±11.9	47.7±11.0	0.138	49.2±11.7	46.1±11.3	0.724	49.7±11.4	46.7±11.7	0.812

Results expressed as median (interquartile range) or mean±standard deviation.

TIMI: Thrombolysis In Myocardial Infarction; LVEF: left ventricular ejection fraction.

Table 5. Association between hospital shifts and 30-day follow-up variables

Variable	Working days	Weekend	p-value	Day shift	Night shift	p-value	Working hours	Non-working hours	p-value
Stent thrombosis	2 (0.9)	1 (1.3)	0.792	3 (1.6)	0	0.195	2 (1.5)	1 (0.6)	0.471
In-stent restenosis	0	1 (1.3)	0.096	0	1 (1.0)	0.178	0	1 (0.6)	0.355
Acute MI	1 (0.5)	2 (2.6)	0.115	3 (1.6)	0	0.195	1 (0.8)	2 (1.3)	0.658
Unstable angina	7 (3.3)	1 (1.3)	0.359	7 (3.8)	1 (1.0)	0.166	6 (4.5)	2 (1.3)	0.095
Stroke	1 (0.5)	0	0.546	1 (0.5)	0	0.456	1 (0.8)	0	0.278
Readmission for any cause	14 (6.6)	6 (7.8)	0.725	17 (9.1)	3 (2.9)	0.046	11 (8.3)	9 (5.8)	0.404
Cardiovascular death	2 (0.9)	1 (1.3)	0.792	1 (0.5)	2 (1.9)	0.259	0	3 (1.9)	0.108
Death from any cause	1 (0.5)	1 (1.3)	0.453	0	2 (1.9)	0.057	0	2 (1.3)	0.190
Combined outcomes	21 (10.0)	8 (10.4)	0.913	21 (11.4)	8 (7.8)	0.333	15 (11.4)	14 (9.0)	0.502

MI: myocardial infarction.

It is important to point out that studies showing longer door-to-balloon time during off-hours had on-call interventional cardiology services to perform primary PCI during this period, whereas in studies that had a 24-hour interventional cardiology staff at the hospital, no difference in door-to-balloon time was observed between groups. The presence of a cath lab team available 24 hours a day and 7 days a week contributes to eliminating the difference in door-to-balloon time between the groups seen at on- and off-hours.²³

The present study did not demonstrate an association between the shift in which primary PCI was performed and the severity and/or complexity of the coronary lesions, assessed by SYNTAX, TIMI frame count, and LVEF. Although it took longer to perform primary PCI during weekends, these findings demonstrated this did not translate into worse coronary flow or worse ventricular function.

Patients who underwent primary PCI during the night shift had a non-significant trend towards higher all-cause mortality when compared to patients undergoing primary PCI during the day shift. Despite the difference in all-cause mortality, the data in the present study showed no difference in cardiovascular mortality. These findings may suggest a possible type I error. Nevertheless, data from a meta-analysis confirmed that patients undergoing primary PCI performed off-hours had higher mortality rates compared to patients submitted to the procedure on-hours. The non-availability of interventional cardiology service 24 hours a day, of trained cardiologists, of diagnostic tests, the reduced number of on-call workers, and human factors (fatigue and sleep deprivation) may have contributed to this finding.²⁴ The increase in 30-day mortality in patients treated during off-hours may have occurred mainly due

to three phenomena: patients undergoing primary PCI during night shift had longer ischemic times, since most were asleep at the onset of symptoms, experiencing chest discomfort at a later stage of the disease; the success of reperfusion may depend on the time of day due to bodily circadian variations, and in part, these may be involved in the success or failure of the procedure, affecting 30-day mortality rates; the quality of care provided may differ through variations in the performance of the physicians, the cath lab and the coronary care team. Quality can be measured, indirectly, by the door-to-balloon time.²⁵ National data have shown higher mortality rates in patients undergoing primary PCI during the night shift compared to patients seen during the day shift. The delay in reperfusion, with increased door-to-balloon time, remains the main reason found by the authors to explain the increase in mortality.²⁶ On the other hand, there are data demonstrating that, despite the longer door-to-balloon time in off-hours groups compared to on-hours groups, mortality does not appear to be different in both groups.^{14,17}

The higher incidence of cases of readmission for any cause, within 30 days, in patients who underwent primary PCI during the day shift compared to those submitted to primary PCI during the night shift seems to be just the result of chance, since it has no plausible justification. Other cardiovascular outcomes followed up in this study (cardiovascular mortality, stent thrombosis, in-stent restenosis, acute MI, unstable angina, stroke and combined outcomes) did not show a significant association with the shift in which the primary PCI was conducted. Since this was an observational study with information bias, errors in the interpretation of the cause of death may have occurred. In addition, the lack of power in the sample may also have contributed to the characterization of death.

The limitations of this study include the impossibility of establishing a cause-effect relation, as well as the short follow-up period for the evaluation of major cardiovascular outcomes. There is no way to rule out the lack of power to assess some outcomes, such as mortality. Outcomes were separately assessed and, therefore, additional factors may have interfered in the difference in mortality. It is also noteworthy that the assessment of door-to-balloon time was not possible in all patients, interfering in the analysis of this variable. Despite the limitations, the data in this study revealed the actual situation of the hospital care in a federative unit, and are relevant to the national literature.

CONCLUSION

The median door-to-balloon time observed was within the time limits recommended by international guidelines. As to hospital shifts, the door-to-balloon time of patients undergoing primary percutaneous coronary intervention during working days was shorter than patients undergoing the same procedure during weekends. There were no significant differences when comparing on and off-hours.

There was also no significant association between the shift in which the primary percutaneous coronary intervention was performed and the risk factors for ST-segment elevation myocardial infarction and severity of coronary lesions. As to the 30-day outcomes, patients seen at night shift showed a non-significant trend towards higher mortality rate from any cause when compared to patients seen during the day shift.

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None.

DECLARATION OF CONFLICTS OF INTEREST

The authors declare there are no conflicts of interests.

CONTRIBUTION OF AUTHORS

Conception and design of the study: FLM and DMM; data collection: FLM, ASF and DMM; data interpretation: FLM, DMM, RLS and TF; text writing: FLM and ASF; approval of the final version to be published: FLM and DMM.

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