Impact of Complications of Myocardial Revascularization Surgery on Expenses During Hospital Stay

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Abstract

Background: Coronary artery bypass grafting (CABG) is an important treatment option for obstructive coronary artery disease, but it represents a high expense for paying sources. The complications of CABG impose an additional expense to the procedure that is not yet clearly established.

Objective: To determine the economic impact of postoperative complications of CABG during hospitalization in a hospital of the unified health system (SUS).

Methods: This is an observational study involving 240 patients undergoing isolated CABG in a reference hospital in cardiology in 2013. Patients aged over 30 years with proven coronary artery disease and indication to perform CRVM were included. Patients who performed CRVM associated with other procedures were excluded.

Results: The average cost of hospitalization was R$ 22,647.24 (SD = R$ 28,105.66). In 97 patients who presented some complication the average cost was R$ 35,400.28 (SD = R$ 40,509.47), and in the 143 patients without complications the average cost was R$ 13,996.57 (SD = R$ 5,800.61) (p < 0.001). Expenditures ranged from R$ 17,344.37 in patients with one complication up to R$ 104,596.52 in patients with five complications (p < 0.001).

Conclusions: The occurrence of complications during hospitalization for CABG significantly increases the costs of the procedure, but the magnitude of this increase depends on the type of complication developed, and higher expenses related to cardiovascular complications, infections and bleeding. With this information, managers can improve the allocation of resources to health. (Int J Cardiovasc Sci. 2019;32(1)28-34)

Keywords: Myocardial Revascularization/economy; Myocardial Revascularization/complications; Hospital Costs/trends; Hospitalization; Cardiovascular Diseases/economy.

Introduction

Cardiovascular diseases are the main cause of mortality worldwide¹, and ischemic heart disease accounts for about 7,500,000 deaths per year.¹ In Brazil, ischemic heart disease causes 107,916 deaths per year.²

Hospital stays and diagnostic and therapeutic procedures related with coronary artery disease (CAD) have a meaningful economic impact on paying sources, as well as treatment-related complications. Complications of surgical myocardial revascularization (CABG) impose additional expenses on the procedure; however, different types of complications determine a varying increase in hospital expenses with CABG. This study aims at determining the economic impact of CABG postoperative complications during stay in a hospital of the Brazilian Unified Health System (SUS).
Methods

This is a single-center observational retrospective study. We selected 240 patients undergoing CABG at the National Institute of Cardiology (INC) in the period from 01 January to 31 December, 2013. We included patients aged over 30 years, of both genders, with coronary artery disease confirmed by coronary angiography and indication for surgical myocardial revascularization after evaluation by the medical staff, composed of a clinical cardiologist, a hemodynamicist and a cardiac surgeon. We excluded patients who had undergone surgical myocardial revascularization combined with other surgical procedures, such as valve surgeries and vascular surgeries.

Hospitalization costs related to medications, laboratory tests, complementary imaging tests, materials, healthcare professionals and other indirect costs, collected from patients’ medical records, were counted in accordance with the data provided by the cost centers. Indirect costs data were obtained from the Transparency Portal of the Brazilian Federal Government. Service agreements and expenses with security, food, information technology, contracting of general services, engineering companies, and maintenance of medical equipment were counted. The consolidated results allowed for the apportionment of the indirect costs per patient day. The costs with healthcare professionals were calculated according with the number of clinical doctors, surgeons, anesthetists, nurses, nursing technicians, physiotherapists, nutritionists and speech therapists who worked in the care of each patient. Subsequently, data related to the wages and workload of each professional were obtained from the Transparency Portal of the Brazilian Federal Government and, with this information, it was possible to estimate the value per hour worked by each professional involved in the healthcare of each patient, in each hospital sector where this patient remained hospitalized. We used the micro-costing method, in which the interventions performed on the patients are individually counted, finally leading to the total hospitalization costs. The values used as basis of cost estimation were obtained from the Table of Procedures and Medications of SUS Managing System (SIGTAP).

Statistical analysis

The statistical analysis of the continuous quantitative variables was carried out by the Student’s t-test, or the Mann-Whitney’s U test, to compare both samples, and the ANOVA test or the Kruskal-Wallis test to compare more than two samples. The results of these analyses were expressed as media and standard deviation. The categorical variables were assessed using the qui-square test or the exact Fisher’s test. The results of the analysis of the categorical variables were expressed as percentage. The assessment of normality was performed using the Kolmogorov-Smirnov test, and the equality of the variances was assessed using the Levene’s test. An α value of 0.05 was determined. The analysis was performed using the IBM SPSS (Statistical Package for the Social Science) software (version 20.0).

The research project was approved by the Ethics Committee in Research of the National Institute of Cardiology (approval number 648.089; CAAE: 30460013.4.0000.5257). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

A total of 240 patients, 169 males and 71 females, who had undergone isolated myocardial revascularization at the National Institute of Cardiology, in 2013, were observed as shown in Table 1.

Mean age was 61.7 years, 60.9 for men and 63.4 for women (p = 0.054). Twenty-four patients were over 75 years of age (10.0%).

The mean time of hospital stay was 32.3 days with standard deviation of 22.7 days. The patients waited, on average, 14.2 days for the surgery, with standard deviation of 8.4. The average recovery period after surgery was 18.4 days, with standard deviation of 20.9 days.

In total, 97 patients incurred complications of some type during hospitalization, corresponding to 40.4% of patients. Complications were grouped into categories related to infectious complications, cardiovascular complications, arrhythmia, bleeding and others, which could not be classified in the other groups, as shown in Table 2.

Direct costs were analyzed by the micro-costing approach and organized into groups relating to medications, laboratory and complementary imaging tests, material and professional costs.

Table 3 shows the average costs per intervention category during hospitalization, and the next sections will demonstrate the costs per category.
Table 1 - Patients’ data

| Demographic profile                                      | n    | %   |
|---------------------------------------------------------|------|-----|
| Age, mean                                               | 61.7 |     |
| Male                                                    | 169  | 70.4|
| Anthropometric data, mean                               |      |     |
| Weight (kg)                                             | 76.2 |     |
| Height (m)                                              | 1.64 |     |
| Creatinine clearance (mL/min)                           | 81.3 |     |
| Body mass index                                         | 28.2 |     |
| Cause of hospitalization                                |      |     |
| Stable CAD without angina                               | 11   | 4.6 |
| Stable angina                                           | 130  | 54.2|
| CCS I                                                   | 8    | 3.3 |
| CCS II                                                  | 43   | 17.9|
| CCS III                                                 | 65   | 27.1|
| CCS IV                                                  | 14   | 5.8 |
| Unstable angina                                         | 40   | 16.7|
| NSTEMI                                                   | 32   | 13.3|
| STEMI                                                    | 23   | 9.6 |
| Others                                                  | 4    | 1.7 |
| Clinical history                                        |      |     |
| Systemic arterial hypertension                          | 229  | 95.4|
| Diabetes mellitus                                       | 110  | 46.0|
| Dyslipidemia                                            | 183  | 76.6|
| Current smoking                                         | 67   | 28.2|
| Previous smoking                                        | 83   | 34.7|
| Sedentary lifestyle                                     | 51   | 21.4|
| Previous MI                                             | 127  | 53.4|
| Previous PTCA                                           | 23   | 9.7 |
| Arrhythmia                                              | 6    | 2.5 |
| Family history of CAD                                   | 39   | 16.4|
| Peripheral artery disease                               | 20   | 8.4 |
| Carotid artery disease                                  | 6    | 2.5 |
| Chronic kidney disease                                  | 19   | 8.0 |
| Chronic obstructive pulmonary disease                   | 11   | 4.6 |
| Alcoholism                                              | 12   | 5.0 |
| Previous stroke                                         | 9    | 3.8 |

| Hypothyroidism                                          | 8    | 3.4 |
| Obesity                                                 | 73   | 30.7|
| Left ventricular function                               |      |     |
| Normal                                                  | 139  | 57.9|
| Mild dysfunction                                        | 33   | 13.8|
| Moderate dysfunction                                    | 31   | 12.9|
| Severe dysfunction                                      | 36   | 15.0|
| Ejection fraction, mean                                 | 55.7 |     |
| Angiographic data                                       |      |     |
| Left main lesions                                       | 30.8 |     |
| Single-vessel disease                                   | 8.7  |     |
| Two-vessel disease                                      | 226  |     |
| Three-vessel disease                                    | 67.8 |     |
| EuroSCORE II, mean                                      | 1.12 |     |

CAD: Coronary Artery Disease; CCS: Canadian Cardiovascular Society (angina pectoris grading system); NSTEMI: non-ST-segment elevation myocardial infarction; STEMI: ST-elevation myocardial infarction.

The mean expenditure of hospitalization was R$ 22,647.24, with a median of R$ 14,772.98 and standard deviation of R$ 28,105.66.

In patients with any complication, corresponding to 97 individuals (40.4%), the mean expenditure was R$ 35,400.28, with standard deviation of R$ 40,509.47, and in those without complications, corresponding to 143 individuals (59.6%), the average expenditure was R$ 13,996.57, with standard deviation of R$ 5,800.61 (p < 0.001).

However, the complications and their associated costs may vary according to each category.

The 17 patients who evolved to bleeding, had a mean hospital expenditure of R$ 37,196.45 (SD = R$ 25,855.71), whereas the 223 patients without bleeding showed an expenditure of R$ 21,538.10 (SD = R$ 28,014.13) (p < 0.021).

The 27 patients with arrhythmia had an average expenditure of R$ 31,760.52 (SD = R$ 22,416.23), whereas the 213 patients without arrhythmia showed an average expenditure of R$ 21,492.03 (SD = R$ 28,583.01) (p < 0.074).

The 37 patients who developed cardiovascular complications showed an expenditure of R$ 45,899.94
Table 2 - Complications in patients undergoing CABG surgery

| Complication                              | N  | %   |
|-------------------------------------------|----|-----|
| Infectious                                |    |     |
| Pneumonia                                 | 16 | 9.7 |
| Mediastinitis                             | 9  | 5.5 |
| Surgical wound infection                  | 9  | 5.5 |
| Urinary tract infection                    | 2  | 1.2 |
| Empiema                                   | 1  | 0.6 |
| Sepsis                                    | 6  | 3.6 |
| Cardiovascular                            |    |     |
| Cardiogenic shock                         | 10 | 6.1 |
| Perioperative myocardial infarction        | 6  | 3.6 |
| Stroke                                    | 6  | 3.6 |
| Pulmonary thromboembolism                 | 1  | 0.6 |
| Cardiac tamponade                         | 2  | 1.2 |
| Pericarditis                              | 1  | 0.6 |
| Acute arterial insufficiency of amputated segments | 3  | 1.8 |
| Arrhythmia                                |    |     |
| Atrial fibrillation                       | 20 | 12.2|
| Atrial flutter                            | 3  | 1.8 |
| Supraventricular tachycardia              | 2  | 1.2 |
| Ventricular Tachycardia                   | 2  | 1.2 |
| Symptomatic Bradycardia or advanced blocks| 5  | 3.0 |
| Bleeding                                  | 15 | 9.1 |
| Others                                    |    |     |
| Acute kidney failure (demanding dialysis) | 14 | 8.3 |
| Pleural effusion                          | 8  | 4.8 |
| Acute abdomen                             | 7  | 4.2 |
| Systemic inflammatory response syndrome   | 6  | 3.6 |
| Pneumothorax                              | 4  | 2.4 |
| Reversed cardiorespiratory arrest         | 3  | 1.8 |
| Digestive bleeding                        | 2  | 1.2 |
| Phrenic paralysis                         | 2  | 1.2 |
| Bronchospasm                              | 1  | 0.6 |
| Convulsion                                | 1  | 0.6 |
| Deaths                                    | 27 | 11.3|

Table 3 - Average costs during hospitalization

| Cost                        | Cost R$ | %  |
|-----------------------------|---------|----|
| Medications                 | 4,673.29| 20.6|
| Laboratory tests            | 592.46  | 2.6 |
| Imaging tests               | 584.83  | 2.6 |
| Materials                   | 2,494.02| 11.0|
| Professionals               | 8,551.77| 37.8|
| Indirect costs              | 5,750.87| 25.4|
| Total                       | 22,647.24|100.0|

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(SD = R$ 56,287.27), and the patients without cardiovascular complications showed an average expenditure of R$ 18,409.06 (SD = R$ 15,902.53) (p < 0.005).

The patients with infectious complications, corresponding to 37 individuals, showed a mean expenditure of hospitalization of R$ 53,949.79 (SD = R$ 56,814.94), whereas the patients without infectious complications showed an expenditure of R$ 16,941.84 (SD = R$ 12,130.63) (p < 0.001).

The additional expenditures for complications, as well as the additional mean length of stay are demonstrated in Table 4.

The occurrence of multiple complications during hospital stay are associated with increased hospitalization costs, as shown in Table 5.

With regard to the intra-hospital mortality, 27 deaths (11.3%) were observed. The mean age of the patients who died was 68.2 years, whereas those who survived had a mean age of 60.9 years (p = 0.001). Mortality in patients who presented with at least one complication was 27.8%.

The patients who died had an average hospitalization cost of R$ 40,497.63, with standard deviation of R$ 44,819.92, whereas those who survived had a mean cost of R$ 20,384.51, with standard deviation of R$ 24,463.07 (p = 0.036).

Table 6 shows the comparisons between the patients who died and those who survived.

Discussion

An understanding of the hospital costs due to CABG-related complications is important because this
is a procedure of high complexity and cost, and it is performed in a large number of patients during the treatment of ischemic cardiac disease, allowing for a rational and evidence-based use of healthcare resources.

In this study, the average cost of hospitalization was higher than that found in other studies carried out in Brazil. A prospective study performed with 103 coronary patients submitted to isolated elective CABG, observed that the average cost of hospitalization was R$ 6,990.30.3

The occurrence of complications is associated with increased hospitalization costs, but this increase depends on the type of complication observed. The most frequent were infectious and cardiovascular complications, followed by arrhythmia and bleeding.

The patients who presented cardiovascular complications, infectious complications and bleeding in the CABG postoperative period had a higher average hospitalization cost than the patients without these complications, because they consumed more material and human resources. In addition, they demanded a longer length of hospital stay.

Twenty-seven patients were diagnosed with arrhythmia-related complications during the postoperative period. The occurrence of atrial fibrillation (AF) was 12.2%, corresponding to 20 patients, a lower percentage compared to the percentage observed in another study, in which 33.6% of the patients presented atrial fibrillation.4 This result is in accordance with a study that observed that atrial fibrillation occurred in 15.2% of the patients analysed5 and another study that observed that atrial fibrillation occurred in 17.2% of patients, being the most frequent complication.6 Another study demonstrated that patients who evolved with atrial fibrillation during the CABG postoperative period had a higher average hospitalization cost compared to the patients without arrhythmia,7 which cannot be confirmed by this study.

Patients who evolved with infectious complications had a higher cost compared to the patients who evolved without nosocomial infections. HILLIS LD et al.,8 demonstrated that nosocomial infections during CABG hospitalization are frequent events, occurring in 10 to 20% of cardiac surgery patients, with superficial wound infection occurring in 2% to 6% of patients after cardiac

| Complications                      | Average costs (± standard deviation) | Additional costs due to complications | Mean length of hospitalization (± standard deviation) | Additional time of hospitalization due to complications |
|------------------------------------|---------------------------------------|---------------------------------------|-------------------------------------------------------|-------------------------------------------------------|
| All patients                       | 22,647.24 (±28,105.66)                | -                                    | 32.3 (±22.7)                                          | -                                                     |
| Patients without complications     | 13,996.57 (±5,800.61)                 | -                                    | 25.3 (±11.6)                                          | -                                                     |
| Patients with any complication     | 35,400.28 (±40,509.47)                | 21,403.71                            | 42.8 (±29.9)                                          | 17.5                                                  |
| Patients with any specific complication compared to all the other patients | | | | |
| Infectious complications           | 53,949.79 (±56,814.94)                | 37,007.95                            | 58.0 (±38.6)                                          | 30.3                                                  |
| Cardiovascular complications       | 45,899.94 (±56,287.27)                | 27,490.88                            | 50.1 (±39.2)                                          | 21.0                                                  |
| Arrhythmia                         | 31,760.52 (±22,416.23)                | 10,268.49                            | 39.8 (±15.9)                                          | 8.4                                                   |
| Bleeding                           | 37,196.45 (±25,855.71)                | 15,658.35                            | 43.6 (±18.1)                                          | 12.1                                                  |

Table 5 - Mean expenditures according with the number of complications

| Number of complications | N  | Mean                  |
|------------------------|----|-----------------------|
| 0                      | 141| 13,996.57             |
| 1                      | 39 | 17,344.37             |
| 2                      | 26 | 38,109.85             |
| 3                      | 13 | 68,789.86             |
| 4                      | 7  | 59,340.00             |
| 5                      | 2  | 104,596.52            |
| Unspecified            | 12 |                       |
| Total                  | 228|                       |

p < 0.001 (Kruskal-Wallis test).
surgery and deep sternal wound infection in 0.45% to 5% of cases. A study conducted in the state of Rio Grande do Sul with 717 patients observed an incidence of infections in the postoperative period of CABG of 19.1%, a higher percentage compared to the percentage found in this study (15.4%). Surgical wound infections after CABG extend the length of hospital stay and increase hospitalization costs. The increase in hospitalization costs was attributed to more frequent use of antimicrobial agents in patients who had nosocomial infection.

Patients with cardiovascular complications also had increased hospitalization cost. A study carried out identified that cardiovascular complications, such as stroke and postoperative shock following CABG increased hospitalization costs, because greater material and human resources were necessary due to extended length of hospital stay.

Patients who had bleeding during the CABG postoperative period had a higher average hospitalization cost compared to patients without bleeding. Other studies also report the impact of this complication on the increase of hospital costs.

The mortality rate observed in this study is similar to the one found in other Brazilian studies, which showed a mortality rate of 13%. Another study carried out in Brazil, in the city of Rio de Janeiro, showed that in-hospital CABG mortality in four hospitals ranged from 7.0% to 14.3%, with a joint mortality rate of 10.9%.

The patients who died had a higher cost compared to the survivors. This result is in accordance with another study performed with 14,780 patients submitted to isolated CABG, which demonstrated that the patients who died had higher hospital costs, with an average cost of US$ 49,242, currently corresponding to R$ 178,748.46.

Among the limitations of this study, we can highlight that it is an observational and retrospective study. Consequently, we depended greatly on the accuracy of the information contained in the medical files to carry out this research. The undertaking of the study in a single reference center may generate questions about the validity of its findings in other hospitals of the SUS where the procedure is performed. Few patients underwent off-pump CABG, which limits the application of this study’s results to this type of surgery.

### Table 6 - Comparison of costs between patients who died and patients who survived

|                               | Deaths | Survivors | \( p^* \) |
|-------------------------------|--------|-----------|-----------|
|                               | Mean   | SD        | Mean      | SD        |
| Days of hospitalization       | 31.1   | 28.3      | 32.5      | 21.9      | 0.816     |
| Age                           | 68.2   | 8.8       | 60.9      | 8.6       | 0.000     |
| Body mass index               | 27.4   | 5.3       | 28.3      | 4.4       | 0.322     |
| Days in intensive care unit   | 19.6   | 26.6      | 6.8       | 12.7      | 0.020     |
| Mechanical ventilation time   | 178.5  | 349.1     | 29.2      | 93.5      | 0.000     |
| Left ventricle ejection fraction | 54.4  | 14.3      | 55.9      | 14.6      | 0.637     |
| Creatinine clearance          | 63.6   | 37.2      | 83.5      | 30.7      | 0.002     |
| Costs of medications          | 11,717.50 | 18,120.39 | 3,780.36  | 9,721.33  | 0.034     |
| Costs of laboratory tests     | 871.80 | 726.64    | 557.05    | 457.81    | 0.036     |
| Costs of imaging tests        | 935.24 | 756.39    | 540.42    | 541.19    | 0.001     |
| Material costs                | 4,477.27 | 3,833.72  | 2,242.62  | 1,318.88  | 0.006     |
| Daily rate costs              | 10,737.76 | 13,509.94 | 5,118.73  | 6,680.65  | 0.042     |
| Healthcare professional costs | 11,758.06 | 12,386.86 | 8,145.34  | 6,788.84  | 0.148     |
| Total costs                   | 40,497.63 | 44,819.92 | 20,384.51 | 24,463.07 | 0.036     |

* * Statistical Analysis performed with the Student’s t test.
Another limitation of this study is related with the non-inclusion of patients who were readmitted precociously due to late surgical complications, since the discharge from hospital can happen before the occurrence of any clinical manifestation.

Conclusions

We conclude that the occurrence of complications during CABG hospitalization significantly increases the expenditures with the procedure, but the magnitude of this increase will depend on the type of complication developed, with the highest costs being related to cardiovascular complications, infectious complications and bleeding.

Author contributions

Conception and design of the research: Barbosa JL. Acquisition of data: Barbosa JL, Silva AFR, Vianna MM, Gedeon POPR, Martins Neto L, Moreira MBUD, Faria LF. Analysis and interpretation of the data: Barbosa JL, Thiers CA, Tura BR. Statistical analysis: Barbosa JL. Writing of the manuscript: Barbosa JL. Critical revision of the manuscript for intellectual content: Barbosa JL, Thiers CA, Tura BR.

Potential Conflict of Interest

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

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Ethics approval and consent to participate

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