

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

João Luís Barbosa,<sup>1,2,4</sup> Clarissa Antunes Thiers,<sup>1</sup> Anderson Ferreira Rolim da Silva,<sup>2</sup> Marcos Maia Vianna,<sup>2</sup> Paulo Otávio de Paula Ravaglia Gedeon,<sup>2</sup> Lauro Martins Neto,<sup>2</sup> Marina Brunner Uchôa Dantas Moreira,<sup>2</sup> Luiz Felipe Faria,<sup>2,3</sup> Bernardo Rangel Tura<sup>1</sup>

*Instituto Nacional de Cardiologia (INC),<sup>1</sup> RJ - Brazil*

*Universidade Estácio de Sá,<sup>2</sup> RJ - Brazil*

*Universidade Fluminense Federal (UFF),<sup>3</sup> Niterói, RJ - Brazil*

*Universidade Federal do Rio de Janeiro (UFRJ),<sup>4</sup> RJ - Brazil*

### 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 worldwide<sup>1</sup>, and ischemic heart disease accounts for about 7,500,000 deaths per year.<sup>1</sup> In Brazil, ischemic heart disease causes 107,916 deaths per year.<sup>2</sup>

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).

#### Mailing Address: João Luis Barbosa

Av. Embaixador Abelardo Bueno, 3250/BL 2/603. Postal Code: 22775-040, Barra da Tijuca, Rio de Janeiro - Brazil.

E-mail: joaoluis@cardiol.br

## 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, anesthesiologists, 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 chi-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  $\alpha$  value of 0.05 was determined. The analysis was performed using the IBM SPSS (Statistical Package for the Social Science) software (version 20.0.0).

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 pulmonar 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		22.6
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	%
<b>Infectious</b>		
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
<b>Cardiovascular</b>		
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
<b>Arrhythmia</b>		
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
<b>Bleeding</b>		
	15	9.1
<b>Others</b>		
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
<b>Deaths</b>		
	27	11.3

**Table 3 - Average costs during hospitalization**

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

(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

**Table 4 - Additional expenditures for complications**

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).

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.<sup>3</sup>

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.<sup>4</sup> This result is in accordance with a study that observed that atrial fibrillation occurred in 15.2% of the patients analysed<sup>5</sup> and another study that observed that atrial fibrillation occurred in 17.2% of patients, being the most frequent complication.<sup>6</sup> 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,<sup>7</sup> 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.,<sup>8</sup> 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

**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.

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%).<sup>9</sup> 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.<sup>10</sup>

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.<sup>11</sup>

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.<sup>11,12</sup>

The mortality rate observed in this study is similar to the one found in other Brazilian studies,<sup>13</sup> which showed a mortality rate of 13%. Another study carried out in Brazil,<sup>14</sup> 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<sup>5</sup> 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.

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.

## Sources of Funding

There were no external funding sources for this study.

## Study Association

This article is part of the thesis of Doctoral submitted by João Luís Barbosa, from *Universidade Federal do Rio de Janeiro* (UFRJ).

## Ethics approval and consent to participate

This study was approved by the Ethics Committee of the UFRJ/*Plataforma Brasil* under the protocol number 648.089, CAAE: 30460013.4.0000.5257. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

## References

- World Health Organization (WHO). World health statistics 2016: monitoring health for the SDGs, sustainable development goals. Geneva;2016.
- BRASIL. Ministério da Saúde. Secretaria Executiva. Datasus. Informações de saúde. [Citado em 2016 nov 01]. Disponível em: <http://www2.datasus.gov.br/DATASUS/index.php?area=02>
- Haddad N, Bittar E, Marchi AF, Kantorowitz CS, Ayoub AC, Fonseca ML, et al. Custos hospitalares da cirurgia de revascularização do miocárdio em pacientes coronarianos eletivos. *Arq Bras Cardiol*. 2007;88(4):418-23.
- Girardi PB, Hueb WA, Nogueira CR, Takiuti ME, Nakano T, Garzillo CL, et al. Comparative costs between myocardial revascularization with or without extracorporeal circulation. *Arq Bras Cardiol*. 2008;91(6):369-76.
- Speir AM, Kasirajan V, Barnett SD, Fonner E Jr. Additive costs of postoperative complications for isolated coronary artery bypass grafting patients in virginia. *Ann Thorac Surg*. 2009;88(1):40-6.
- Osnabrugge RL, Speir AM, Head SJ, Jones PG, Ailawadi G, Fonner CE, et al. Prediction of costs and length of stay in coronary artery bypass grafting. *Ann Thorac Surg*. 2014;98(4):1286-93.
- Almassi GH, Wagner TH, Carr B, Hattler B, Collins JF, Quin JA, et al. Postoperative atrial fibrillation impacts on costs and one-year clinical outcomes: the veterans affairs randomized on/off bypass trial. *Ann Thorac Surg*. 2015;99(1):109-14.
- Hillis LD, Smith PK, Anderson JL, Bittl JA, Bridges CR, Byrne JG, et al. ACCF/AHA Guideline for Coronary Artery Bypass Graft Surgery: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2011;124(23):e652-735.
- Ledur P, Almeida L, Pellanda LC, Schaan BD. Predictors of infection in post-coronary artery bypass graft surgery. *Braz J Cardiovasc Surg*. 2011;26(2):190-6.
- Kobayashi J, Kusachi S, Sawa Y, Motomura N, Imoto Y, Makuuchi H, et al. Socioeconomic effects of surgical site infection after cardiac surgery in Japan. *Surg Today*. 2015;45(4):422-8.
- Brown PP, Kugelmass AD, Cohen DJ, Reynolds MR, Culler SD, Dee AD, et al. The frequency and cost of complications associated with coronary artery bypass grafting surgery: results from the United States Medicare program. *Ann Thorac Surg*. 2008;85(6):1980-6.
- Kilic A, Shah AS, Conte JV, Mandal K, Baumgartner WA, Cameron DE, et al. Understanding variability in hospital-specific costs of coronary artery bypass grafting represents an opportunity for standardizing care and improving resource use. *J Thorac Cardiovasc Surg*. 2014;147(1):109-15.
- Sá MP, Soares EF, Santos CA, Figueredo OJ, Lima RO, Escobar RR, et al. EuroSCORE and mortality in coronary artery bypass graft surgery at Pernambuco Cardiologic Emergency Medical Services. *Rev Bras Cir Cardiovasc*. 2010;25(4):474-82.
- Oliveira TM, Oliveira GM, Klein CH, Souza E Silva NA, Godoy PH. Mortality and complications of coronary artery bypass grafting in Rio de Janeiro, from 1999 to 2003. *Arq Bras Cardiol*. 2010;95(3):303-12.

