

Coronary Artery Bypass Graft Surgery Performance and Costs by the Brazilian Public Health System (SUS) in the State of Rio de Janeiro, from 1999 to 2008

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Abstract

Background: Expenses with coronary artery bypass grafting (CABG) surgery and coronary angioplasty (CA) represented a significant cost to SUS.

Objective: To analyze SUS expenses with CABG and CA and their performance in hospitals in the state of Rio de Janeiro (SRJ), from 1999 to 2008.

Methods: The information came from paid HAA in hospitals with more than 100 revascularization procedures. Mortality rates were adjusted by Poisson (with covariates age, length of hospital stay and ICU expenses). Mean relative cost indices were calculated by dividing the mean value of the cost fraction spent in each hospital by the mean expense in the SRJ in U.S. dollars. Stata software was used for statistical analysis.

Results: A total of 10,983 CABG and 19,661 CA were paid by SUS in 20 hospitals during the 10 years, with mean values of US\$ 3,088.12 and 2,183.93, respectively. The mortality rate in CABG varied from 9.2%-1999 to 7.7%-2008, with ranges of 5.0%-9.2% and in CA, from 1.6%-1999 to 1.5%-2008, with ranges of 0.9%-2.3%. The hospitals decreased the number of CABG procedures and doubled CA procedures. Age, time of hospital stay and ICU costs significantly correlated with lethality in CABG and CA paid by SUS in the SRJ. On average, hospital service costs represented 41% of the total cost of CABG and 18% of CA, and with orthoses and prostheses, 55% in CA and 28% in CABG.

Conclusion: It is clear the need to improve the quality of healthcare service in institutions that perform CABG and CA paid by SUS. (Arq Bras Cardiol 2011;97(4):297-306)

keywords: Health care costs; myocardial revascularization/economics; unified health system.

Introduction

Coronary artery disease (CAD) accounted for 29.4% of deaths in the state of Rio de Janeiro (RJ) in 1999. In 2007, this percentage remained virtually unchanged (28.8%). In 1999, cerebrovascular disease (CVD) accounted for 32.7%, while ischemic heart disease (IHD) accounted for 31.9% of CAD. This relationship was reversed in 2007, when those percentages were 30.2% and 31.5%¹.

Soares et al², studying mortality due to CAD in the SRJ regions from 1980 to 2007, concluded that the decrease in mortality due to CVD has occurred continuously since 1980, and IHD mortality showed slight fluctuations until 1990 and then showed relevant decreases². In the analysis of decreasing mortality trends due to IHD, multiple factors must be considered, including age, sex, diagnosis, therapeutic interventions and environmental and socioeconomic conditions. The studies with data recorded from clinical

practice provide a view that is closer to reality than the experimental ones³.

In a study with samples of coronary angiography (CA) records performed in public hospitals in the city of Rio de Janeiro (CRJ), from 1999 to 2003, a mean in-hospital mortality of 1.6% was observed, ranging from 0.9% to 6.8%. Mortality rates in primary and rescue CA were 17.4% and 13.1%, and in elective CA, it was 0.8%⁴. During the same period, in 2,692 coronary artery bypass graft (CABG) records in the CRJ, a variation between hospitals was observed, from 7.0% to 14.3% in the in-hospital period, and 8.5% to 20.2% up to one year post-hospital release and a significant association between the occurrence of complications and postoperative death ($p < 0.0001$)⁵. Therefore, regarding myocardial revascularization procedures, the minimum required performance was not observed in the SRJ⁶, representing an important financial burden for the Brazilian Public Health System (SUS), with individual and social consequences⁷.

In the middle of the last decade of the twentieth century, it was estimated that 80% of medical or hospital care was financed by the Public Health System (SUS) in Brazil⁸. From 1999 to 2003, SUS spent annually in the State of Rio de Janeiro (SRJ), on average, 191 million dollars with all-cause hospitalizations. This figure represented an annual expenditure of US\$ 13.20 per capita, of

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Manuscript received November 11, 2010; revised manuscript received
December 21, 2010; accepted March 29, 2011.

which US\$ 0.60 was spent on hospitalizations due to IHD. About 70% of the average annual value of US \$ 8.7 million spent in hospitalizations due to IHD corresponded to CA or CABG. These procedures were performed in one fifth of hospitalizations due to IHD, of which 37% were CABG and 63% CA³.

This article aims at analyzing SUS expenses with CA and CABG performed in hospitals in the SRJ, from 1999 to 2008, and the performance of these procedures evaluated by mortality rates, adjusted for age, length of hospital stay and intensive care unit (ICU) costs.

Methods

Information on the procedures came from the databases of Hospital Admission Authorization (HAA) forms, from January 1999 to December 2008, available at the site of Datasus/MS¹. The following codes were considered for CABG: 32039018, 32011016, 32038011, 48010073, 48010081, 48010090, 32040016, 48010103, 406010927, 406010935, 406010943 and 406010951, excluding those with valve replacement. For CA the following codes were used: 32035012, 32023014, 48030066, 48030082, 48030074, 48030112, 48030090, 48030104, 406030014, 406030022, 406030030, 406030049, 406030065 and 406030073.

Hospitals were identified by letters, individualizing those that performed 100 or more CABG or CA in the period¹. The others were grouped into a single category. Hospitals A, B, C and D are public in the city of Rio de Janeiro (CRJ), while the others are private and accredited by SUS. The public hospital, S, in the Metropolitan Region, performed a paid CA in the period and was included in the "others" category. Hospitals A, B and I are University hospitals, and C and D are reference cardiology centers in SUS.

It was considered that factors such as age, ICU length of stay in days and costs, due to their potential association with clinical severity, influenced mortality, with mortality rates of hospitals being adjusted using Poisson models with covariates age, ICU stay and costs. To calculate the age variable, we used the difference between the date of admission and date of birth obtained from HAA or, in their absence, the age recorded in the HAA. The ICU time was obtained from the HAA or by the difference between the dates of hospital release and admission, as long as it was less than one year.

The unit of cost measurement was U.S. dollars. The dollar rate was obtained by the ratio between the values of total expenses in Brazilian Reais and in U.S. dollars, reported in HAA. These rates were used to estimate the values in dollars of the fractions that make up the total expense, which were: professional services (Prof. Serv), hospital services (Hosp. Serv.) Ortheses and prostheses (Ort/Prot.), Auxiliary services of diagnosis and therapy (ASDT), and intensive care unit (ICU). Mean relative cost indices were calculated by dividing the mean value of the cost fraction spent in each hospital by the mean expense in the SRJ in U.S. dollars.

Charts were constructed with the annual variation of CABG and CA in hospitals that performed at least 300 procedures during the period. For the estimates of mortality rates and analysis of the other results, Stata software was used⁹.

Results

Table 1 shows the 30,644 CABG and CA procedures performed and paid for by the SUS in the SRJ from 1999 to 2008 in the hospitals. CA was performed 1.8 times more than CABG. It was observed that 35.2% of procedures were performed in hospitals A, B, C and D, which were reference and public hospitals in the capital city. Hospitals G and J in the countryside of the SRJ were the ones that performed the highest number of procedures, 29.4% of the SRJ. Hospital G performed relatively more CA (19.6%) and J more CABG (14.5%) procedures.

Figure 1 shows the annual frequency of CABG in the eleven hospitals with 300 or more procedures in the period. There was no large variation in the frequency of CABG, which ranged from 1,000 to 1,200 annual surgeries. The public hospitals in the CRJ, A and B, decreased the number of CABG procedures, while hospitals C and D showed complementary variation, i.e., when the production is reduced in one, it increases in the other and vice versa. Hospital J, private, with more paid CABG procedures, gradually decreased its production. Hospitals

Table 1 – Coronary artery bypass grafting procedures (CABG) and coronary angioplasty (CA), paid by SUS, carried out in the state of Rio de Janeiro, from 1999 to 2008

HOSPITAL	PROCEDURE		TOTAL
	CABG	CA	
A	547	1.104	1.651
B	1.632	310	1.942
C	1.334	2.617	3.951
D	1.041	2.212	3.253
E	352	1.649	2.001
F	945	1.486	2.431
G	1.127	3.849	4.976
H	775	867	1.642
I	554	934	1.488
J	1.581	2.438	4.019
K	184	64	826
L	283	889	1.172
M	205	196	401
N	12	35	47
O	306	178	484
P	33	86	119
Q	51	4	55
R	11	54	65
R	0	1	1
T	10	110	120
TOTAL	10.983	19.661	30.644

CABG - coronary artery bypass graft; CA - coronary angiography.

Original Article

F and G increased their production during most of the period. Hospitals E, H and I showed virtually unchanged productions. Hospital O, in the Mid-Paraíba Region, has performed CABG since 2006 and has gradually increased its production.

Figure 2 shows the annual frequency of CA performed by the eleven hospitals with 300 or more procedures during the period. In the hospitals of the SRJ, there was a tendency toward doubling the number of CA procedures. Hospitals A and B, which were university and public hospitals in the CRJ, showed stable amounts of CA, except in the years 2004-2005 at hospital A. Hospital C, a reference in cardiology treatment in the SRJ, increased CA until 2006, and thereafter, showed decreased production. Hospital D, also a state reference in cardiology, increased its production until 2003, reducing it by 2006, when it increased again. Hospital G, with more CA paid by SUS, increased its production until 2004, when it started to perform decreasing numbers of CA.

The other hospitals in the countryside performed increasing numbers of CA, except for University Hospital I, in the northern region, which maintained a stable production.

Hospital L, in the Serrana region, performed CA from 2002 onward, increasing its production until 2004, which then declined.

Table 2 shows the mean costs in dollars, paid by SUS in CABG procedures in the SRJ, distributed among Prof. Serv., Hosp. Serv., Ort./Prot., ASDT and ICU, when these expenses are available (N). The mean relative costs (MRC) per hospital and fractions are shown in the table, taking as reference the means of the SRJ. Costs related with Hosp. Serv. and Ort./Prot. represent about two thirds of the total. The greatest discrepancy in total costs occurred in hospital N, about 1.9 times higher than in hospitals C and K. Hospital N, a private hospital in the CRJ showed costs that were two-fold higher than the state average in Hosp. Serv., and 1.8-fold higher in Ort./Prot. Hospitals A and B, university hospitals, and Q showed values that were proportionally higher in Hosp. Serv. Hospital R showed a MRC with a very high ICU fraction, but there were only five statements in 11 hospitalizations. Hospitals P and T did not report most costs, concentrating them in the ICU, more than twice the state average.

Table 3 shows the mean costs in dollars paid by SUS, in CA procedures in the SRJ, distributed as Prof. Serv., Hosp. Serv., Ort./Prot., ASDT and ICU, when these expenses are available (N). The Mean Relative Costs (MRC) per hospital and fractions are shown in the table, taking as reference the means of the SRJ. Costs related with Ort./Prot. represent more than half of CA expenses in the SRJ. The discrepancies in total expenses between hospitals seem very large when

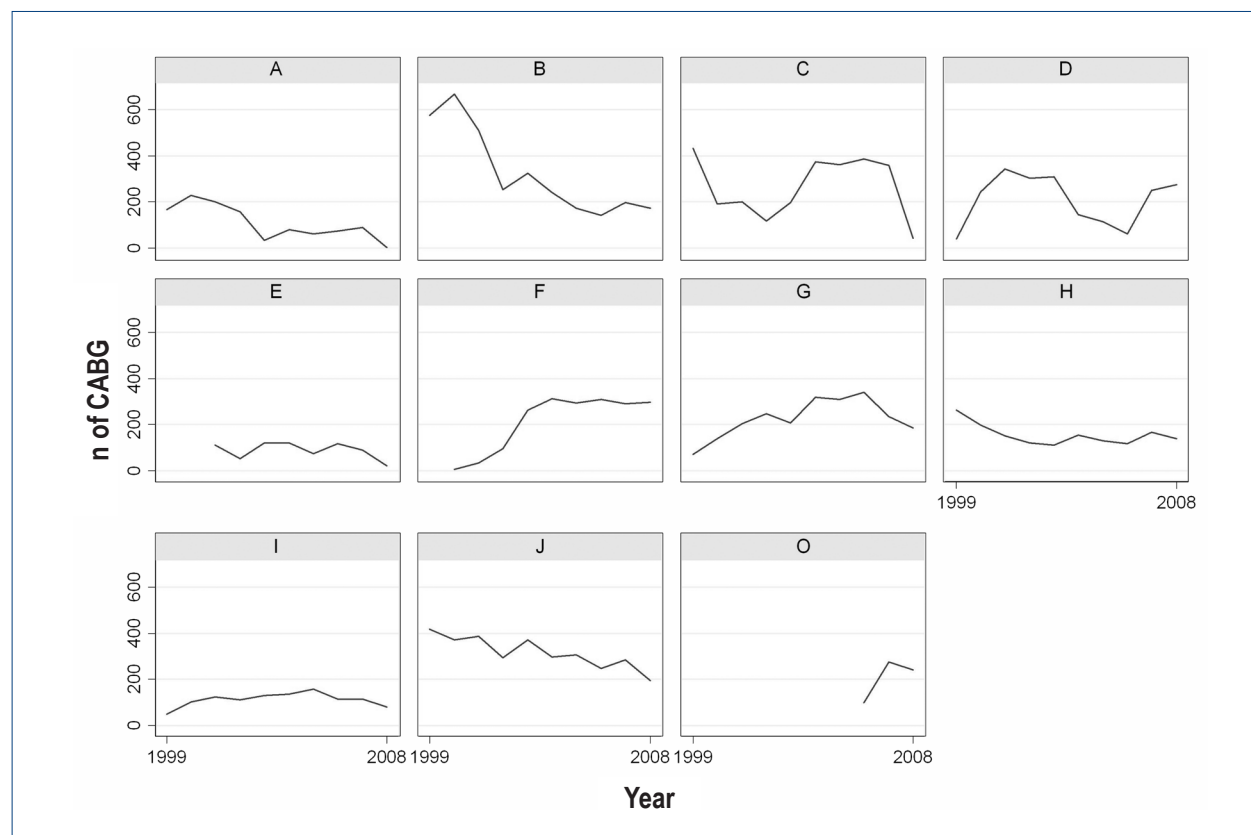


Figure 1 – Surgical myocardial revascularizations, CABG, paid by SUS in hospitals with 300 or more procedures, 1999-2008. n of CABG - number of surgical myocardial revascularization procedures performed; Year - year when the CABG was performed.

comparing the hospitals O, with the highest costs, with Hospital R, with the lowest (hospital Q was disregarded as it had declared only four CA). Hospital G showed very high costs G with Ort./Prot., with the state average as a reference.

Hospital N showed high expenses with Hosp. Serv., at the same level of those paid to university hospitals. Hospitals P and T reported only the ICU and total costs. There was a wide variation in ICU costs, which was high in hospitals B, R and J. On average, costs with a CA corresponded to 71% of the value of a CABG. However, of the total of about US\$ 76 million and 855,000 spent on the two procedures by SUS, 55.9% of these resources were used to pay for CA.

Table 4 shows adjusted mortality rates in the CABG paid in the SRJ, as well as mean age and ICU length of stay and expenses with survivors or deaths in hospitals. Mortality rates were adjusted for the covariates described above, with Poisson models. Age, length of ICU stay and costs significantly correlated with mortality in CABG.

However, adjusted mortality rates in CABG are virtually identical to the non-adjusted ones, with an increase of only 0.1% in A, E and L, and decrease of 0.1% in C. This shows that the covariates considered do not alter the hierarchy and the level of rates between hospitals. Mortality rates ranged from 2.4% in hospital J to 12.1% in hospital B, the ones

which performed more CABG procedures, from 1999 to 2008. Hospital E and the group of "other hospitals" (fewer than 100 procedures during the period) had mortality rates above 10%. Only three hospitals had mortality rates < 5%.

There were no significant differences between the mean age of the survivors, which ranged between 58.7 and 62.1 years. Among the deaths, the greatest discrepancy occurred between the mean age of 58.2 and 70.4 years, and the biggest difference between survivors and deaths occurred in hospital L. The mean age of patients who died was higher than that of survivors in almost all hospitals, with one exception (K). In about half of the hospitals, the length of stay was shorter in cases of death.

These lengths of stay were higher, in both survivors and deaths in public hospitals compared to private ones in the CRJ. Only two hospitals had length of stay of up to seven days (F and O). We observed significant variations in mean costs with intensive care in the hospitals, especially in cases of death. With the exception of hospitals E, G and K, ICU costs were higher in cases of death (Table 4).

Table 5 shows adjusted mortality rates in CA paid in the SRJ as well as patients' mean age and ICU length of stay and costs of survivors or deaths in the hospitals. Mortality rates were adjusted as described for CABG. Age, ICU length of

Table 2 – Mean relative costs (MRC) and means of the fractions in dollars in CABG paid by SUS in the state of Rio de Janeiro, from 1999 to 2008

Hospital Mean	Prof. Serv. 324,17	Hosp. Serv. 1.252,96	Ort./Prot. 849,37	ASDT 45,53	ICU 297,22	Total 3.088,12
A	1,25	1,24	0,82	1,28	1,09	0,96
B	1,19	1,20	0,65	1,12	1,27	0,95
C	1,11	1,08	0,71	1,20	0,96	0,88
D	0,89	0,83	0,86	0,84	0,73	0,92
E	0,90	0,83	1,39	0,88	0,51	0,94
F	0,83	0,68	0,98	0,76	0,34	0,92
G	0,92	1,06	1,54	0,88	0,56	1,16
H	0,98	0,96	1,21	1,02	1,34	1,04
I	1,08	1,12	1,19	1,14	1,19	1,12
J	0,96	1,02	1,26	1,04	1,39	1,08
K	0,91	0,96	1,09	0,76	0,33	0,88
L	0,85	0,98	0,53	0,99	1,46	1,03
M	0,89	0,94	1,52	1,07	1,06	0,98
N	0,99	2,27	2,02	1,05	0,56	1,65
O	0,84	0,71	0,60	0,85	1,20	1,16
P	0,00	0,00	0,00	0,00	2,43	1,33
Q	1,30	1,28	0,11	0,95	0,94	1,04
R	0,14	0,11	0,00	0,12	1,93	1,01
T	0,00	0,00	0,00	0,00	2,90	1,21
SRJ	1	1	1	1	1	1

Prof. Serv. - Professional Services; Hosp. Serv. - Hospital Services; Ort.Prot. - Ortheses/Prostheses, ASDT- auxiliary services of diagnosis and therapy, ICU - intensive care unit.

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stay and costs were significantly correlated with mortality in CA. However, adjusted mortality rates in CA are almost identical to non-adjusted ones, with an increase of only 0.1% in C. Mortality rates after CA varied significantly. There were no deaths in Hospitals E, K and O, and in T, 6.4% of patients undergoing CA died during the hospitalization. Hospitals A, B and I, university hospitals and H, J, L and T, in the countryside of the SRJ, had mortality rates higher than the state averages, above 1.8%.

There were no significant differences between the mean age of survivors, but among the dead, these means ranged between 57.0 and 69.2 years. The mean length of stay was high in both survivors and deaths in public hospitals in the CRJ. Hospitals E, F, G, K, M and O had mean length of stay close to three days with mortality rates below 1.0%, except in G. There were noteworthy variations in mean ICU costs in the hospitals, especially among deaths. Except for hospitals A, E, F and M, the ICU costs were higher in deaths. The hospital with the highest mortality rate, T, declared one of the highest costs with ICU. Hospital M declared one death and did not declare costs with ICU (Table 5).

Discussion

The observed results show the vital need to implement measures that can improve the quality of care in CABG and

CA. It can be seen that the number of CA increased, surpassing that of CABG, with increasing costs for the healthcare system. These costs could be justified if the performance was adequate with reduced mortality. To obtain similar performance between CABG and clinical treatment, the in-hospital mortalities should be < 2.5%, even in patients with stable multi-vessel disease and documented ischemia¹⁰.

The high mean length of stay (in CABG, 17.5 days in survivors and 20.8 days in deaths and in CA, 4.2 and 7.7 days for survivors and deaths, respectively) suggest the occurrence of complications, which must have contributed to the increase in costs. Another study, using the same database, conducted between 1999 and 2003, showed that during the performance of CA, coronary dissection occurred in 5% and vessel occlusion in 2.6%, with a mortality rate of 11.5% and 21.8%, respectively. Moreover, bleeding occurred in 5.9%, with a mortality rate of 5.6%, among which there was need for transfusion in 3.0%, with a mortality rate of 12.0%. Acute myocardial infarction occurred in 1.1%, with a mortality rate of 38% and cerebrovascular accident in 0.4%, with a mortality rate of 17.5%⁴. Regarding the CABG in the same period, complications occurred in more than 99% of deaths, while even among the survivors, 40% had complications. Almost 60% of deaths had five or more complications, which occurred in less than 7% of survivors⁵.

Azambuja et al¹¹, in a conservative estimate about the economic impact that severe CAD, which affects 5% of the

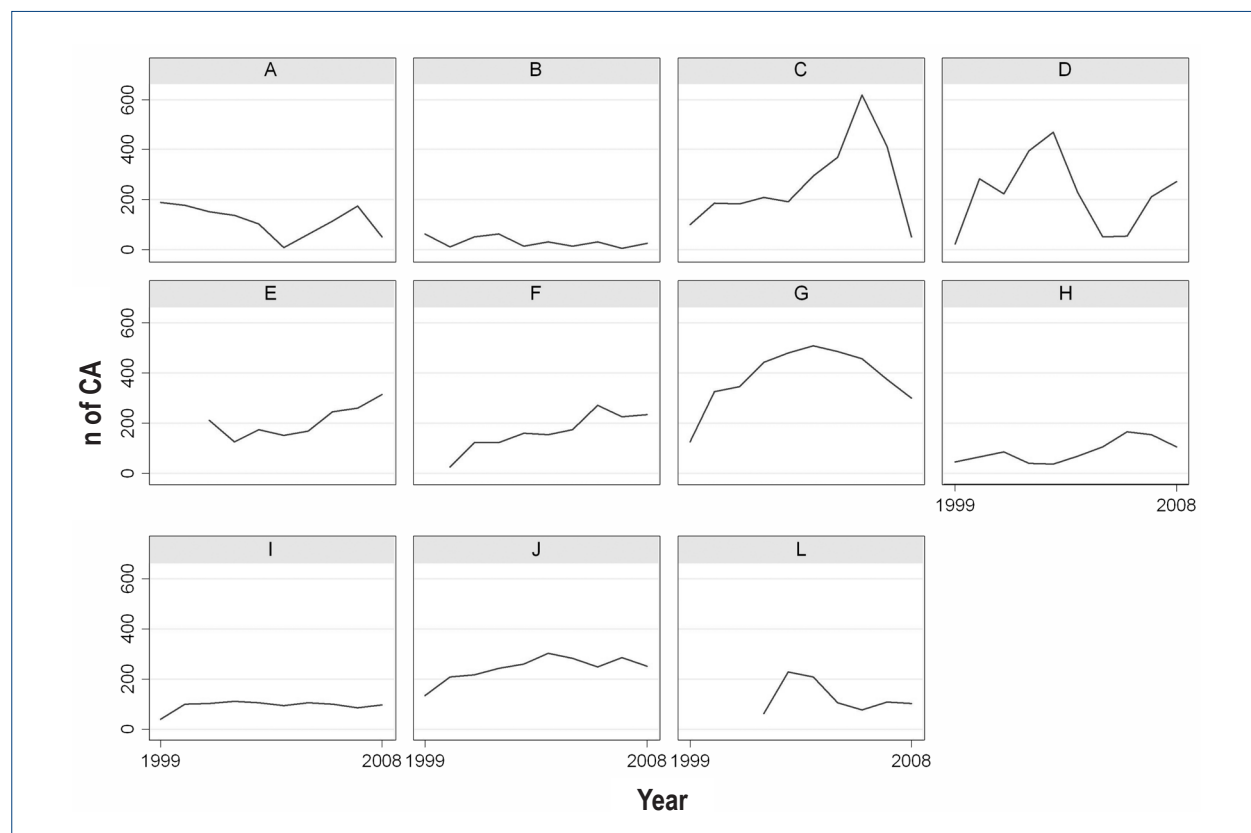


Figure 2 – Myocardial percutaneous revascularizations, CA, paid by SUS in hospitals with 300 or more procedures, 1999-2008. n of CA - number of coronary angiography procedures; Year - year when the CA was performed.

Table 3 – Mean relative costs (MRC) and means of the fractions in dollars in CA paid by SUS in the state of Rio de Janeiro, from 1999 to 2008

Hospital Mean	Prof. Serv. 168,98	Hosp. Serv. 400,83	Ort./ Prot 1.199,05	ASDT 69,29	ICU 92,64	TOTAL 2.183,93
A	1,29	1,48	0,97	1,48	1,75	1,02
B	1,11	1,61	0,84	1,54	2,68	1,00
C	1,08	1,00	1,11	1,16	1,02	0,95
D	0,95	0,69	0,92	0,80	0,46	0,90
E	0,93	0,68	0,88	0,85	0,55	0,96
F	0,96	0,73	0,94	0,88	0,84	0,96
G	1,11	1,32	1,18	0,97	0,60	1,12
H	0,86	0,95	1,03	1,08	1,64	1,04
I	1,18	1,29	0,96	1,25	1,88	1,04
J	0,85	0,92	1,07	0,97	1,22	1,05
K	1,10	0,95	0,82	1,14	0,61	0,75
L	0,86	0,99	0,87	0,96	1,34	0,91
M	0,95	0,90	0,99	1,01	1,04	0,81
N	1,04	1,72	1,09	1,37	0,72	1,04
O	0,58	0,36	0,58	0,47	1,03	1,29
P	0,00	0,00	0,00	0,00	2,54	1,16
Q	1,04	0,88	0,06	1,12	0,00	0,43
R	0,16	0,15	0,09	0,16	1,82	0,49
S	0,00	0,00	0,00	0,00	0,00	1,06
T	0,00	0,00	0,00	0,00	2,70	1,21
SRJ	1	1	1	1	1	1

Prof. Serv. - Professional Services; Hosp. Serv. - Hospital Services; Ort.Prot. - Ortheses/Prostheses, ASDT- auxiliary services of diagnosis and therapy, ICU - intensive care unit.

Table 4 – Rates of Mortality (%)* and means of age, length of ICU stay and costs in survivors and deaths, in CABG procedures paid by SUS in the state of Rio de Janeiro, from 1999 to 2008

HOSPITAL	Mortality (%)	Age (S/D)**	ICU stay duration (S/D)**	ICU-US\$ (S/D)**
A	9,4	61,3/66,1	35,1/34,1	318,83/383,52
B	12,1	60,8/64,6	23,8/26,0	355,37/542,57
C	6,3	61,0/65,4	33,3/38,3	270,37/489,57
D	7,7	60,5/64,4	20,6/27,3	206,01/334,89
E	11,5	59,8/64,2	9,0/5,0	152,71/143,75
F	3,3	62,1/68,3	6,1/5,9	95,61/222,62
G	7,3	60,9 /63,0	8,0/10,0	168,18/154,96
H	5,0	61,2/62,5	12,4/10,5	380,48/756,00
I	8,5	62,0/67,1	14,7/12,1	337,15/528,89
J	2,4	61,5/64,9	15,2/18,7	388,24/1454,56
K	4,9	59,1/58,2	7,3/ 11,2	100,87/44,83
L	5,0	61,1/70,4	8,7/9,0	405,20/968,56
M	3,4	62,4/ 66,6	9,6/7,7	309,53/460,20
O	6,5	58,7/ 64,7	6,3/7,0	340,52/599,98
Others	11,1	60,8/66,9	19,4/8,2	465,36/511,06
Total (SRJ)	6,9	61,1/64,9	17,5/20,8	283,31/485,67

**Adjusted by Poisson with covariables age, ICU stay duration and costs; **S - hospitalization survivors; D - died during hospitalization.*

Table 5 – Rates of lethality (%)* and means of age, ICU stay duration and costs in survivors and in patients who died, in CA procedures paid by SUS in the state of Rio de Janeiro, from 1999 to 2008

HOSPITAL	Mortality(%)	Age (S/D)**	ICU stay duration (S/D)**	ICU-US\$ (S/D)**
A	1,9	61,0/ 69,0	9,3 /14,9	161,78/ 158,52
B	3,9	60,5/ 65,9	13,9/ 14,8	230,82/684,78
C	0,7	59,8/ 65,0	5,3/9,8	93,40/233,62
D	1,0	59,4/ 62,6	4,3/20,0	38,28/490,20
E	0,0	59,7/ -	3,2/-	51,08/-
F	1,0	60,7/65,4	2,1/0,7	77,98/ 62,27
G	1,3	60,2/68,3	2,8/5,0	55,28/53,94
H	2,1	60,0/64,4	5,0/3,3	151,22/184,35
I	4,2	59,7/63,6	6,0/2,7	172,63/214,99
J	2,7	62,4/69,2	3,6/9,8	100,58/560,12
K	0,0	59,9/-	2,6/-	56,36/-
L	4,3	60,7/66,1	3,9/3,5	120,73/204,37
M	0,5	60,3/57,0	3,0/0,0	96,46/0,0
O	0,0	60,3/-	1,3/-	95,80/-
T	6,4	62,0/61,7	4,0/6,4	215,86/761,32
Others	1,1	60,7/59,0	5,0/2,5	175,69/176,84
Total (SRJ)	1,6	60,3/66,4	4,2/7,7	89,36/299,44

*Adjusted by Poisson with covariables age, ICU stay duration and costs; **S - hospitalization survivors; D - died during hospitalization.

population 35 or older represented for Brazil in 2004, observed that the annual cost was at least R\$ 30.8 billion, equivalent to R\$ 500.00 per capita and R \$ 9,640.00 per patient. These direct costs in healthcare represented 8% of the country's total expenses with health and 0.52% of the GDP¹⁰. Expenses should increase significantly in the coming decades with the aging of the population¹¹.

Balbinotto Neto e Silva¹², in an editorial commenting on the previous article, point out that the approach of studies on disease costs is a partial economic evaluation, by taking into consideration only the costs of resources and not the gains from reduced illness and treatment results. To provide effective assistance to health administrators, it would be necessary to compare them with the alternative allocation of resources¹². The expenses have also been increasing due to the increased use of CA.

Statistics on health costs can reveal or hide interesting facts. Those who spend the most do not always get the best results. Table 6 describes, in the year 2009, total healthcare costs, the percentage allocated by public resources, the percentage of GDP spent on healthcare and life expectancy at birth in some countries. Although the expenses refer to the year 2009, they possibly reflect past policies. In the United States, including public and private expenses, they spent twice what was spent in France, the second in *per capita* gross expenditure, and about nine times what was spent in Brazil. However, the U.S. government paid much less, in terms of percentage, than the others, with the exception of Brazil, with the two being, incidentally, very similar.

Concerning the GDP, it may seem strange that so much is spent in the United States, but we must remember that the pharmaceutical industry, equipment and healthcare service sectors in that country must represent more than in Brazil and Argentina, yet possibly not much more than in France and the United Kingdom. Japan seems to have the best policy for allocation of resources at appropriate levels, without directly

Table 6 – Statistics of health-related costs and life expectancy in some selected countries - 2009

Countries	Total health-related costs per capita (dollars) *	% of government's health-related costs*	% of GDP spent with healthcare*	Life expectancy at birth **
Argentina	1322	50,8	10,0	76,6
Brazil	837	41,6	8,4	72,0
Canada	3900	70,0	10,1	81,2
USA	7285	45,5	15,7	78,1
France	3709	79,0	11,0	80,9
Japan	2696	81,3	8,0	82,1
United Kingdom	2992	81,8	8,4	79,0

* WHO Health Statistics 200913; ** Estimates CIA Factbook 200914.

placing the burden on the citizens with the best results regarding life expectancy^{13,14}.

The direct cost related to the management of IHD is high in Brazil, with considerable impact on the health financing agencies, especially related to drug expenses and high-complexity attention, making it a challenge to incorporate new technologies¹⁵⁻¹⁷. In the UK, in 2000, the cost of management of chronic IHD was 669 million sterling pounds in 634,000 individuals, of which 35% with revascularization procedures¹⁸. In Brazil, in 2000, R\$ 232.7 million reais were spent with hospitalizations paid by SUS for the treatment of IHD¹. In 2003, SUS expenses were about R\$ 281 million to perform 30,666 CA and 19,909 CABG¹⁷.

In 1997, of the SUS expenses with hospitalizations in Brazil, 3.3% were due to IHD⁸, whereas in the SRJ this relative cost was 4.6% from 1999 to 2003. Almost 70% of the average annual value of US\$ 8.7 million spent in hospitalizations due to stable IHD corresponded to CABG and CA procedures³. These patients have low to moderate risk with estimated annual rates of mortality below 3%¹⁹. In Brazil, from 2005 to 2007, 63,529 CABG procedures were paid by SUS in 191 hospitals, with a mean mortality rate of 6.22%. This mortality was higher in low-volume hospitals than in large-volume ones (≥ 300 surgeries in the period), 7.29% versus 5.77% ($p < 0.001$). The mean hospital stay was 12 days. The mean value of paid HAA was R \$ 6,900.16 in public hospitals and R \$ 6,864.74 in private ones²⁰.

In the SRJ, from 1999 to 2008, SUS paid for 30,644 myocardial revascularization procedures, totaling 19,661 CA and 10,983 CABG in 20 hospitals (Table 1). The mean mortality rates were 6.9% for CABG (2.4% to 12.1%) and 1.6% in CA (0 to 6.4%). Mortality was not directly related to the volume of CABG in the SRJ (Table 1 and Table 4). The same happened with the different CA mortality rates in the four hospitals with more procedures, ranging from 0.7% to 2.7% (Table 1 and Table 5). In Brazil, the mortality of the 55 hospitals that performed 100 or more procedures in three years ranged from about 2% to 19%, and the hospitals had different amounts of annual procedures²⁰. In the SRJ, the provision of CABG for the population decreased gradually, with service delay being presupposed (Fig. 1), if we take into account the population growth in the period. This might be one explanation for the high mortality in the state²¹.

The mortality rates in the SRJ due to myocardial revascularization were similar to those observed by Ribeiro et al., in HAA, in 65,716 procedures between 2003-2004²². However, these rates are high compared to those of other studies. In New York, from 2003 to 2005, in 40,429 patients, a 30-day mortality rate of 2.14% was observed²³. Mortality at one year was 0.8% in CABG and 2.5% in CA in 988 randomized patients (488 CA and 500 CABG) from 1996 to 1999, in 11 European countries and Canada²⁴. In 445 high-risk patients, followed for three years, the reported rates were 0.79% for CABG and 0.82 for CA²⁵.

A study carried out at the Institute Dante Pazzanese of Cardiology in 103 CABG reimbursed by SUS in 2005, showed a mean cost of US\$ 2,784.98, with a minimum

cost of US\$ 2,166.81 and a maximum cost of US\$ 4,692.81. The highest mean costs were in the operating room (R\$ 4,627.97) and in the immediate postoperative period (R\$ 1,221.39), followed by the nursing care after the immediate postoperative period (R\$ 840.04) and the initial preoperative nursing care (R\$ 300.90)²⁶. In the SRJ, the mean relative cost was higher in most hospitals, of US\$ 3,088.12. Expenses with Hosp. Serv. represented on average about 40% (US\$ 1,252.96), followed by Ort./Prot. with 27% (US\$ 849.37) of the total (Table 2).

Almeida²⁷ compared the costs of CABG and CA in 86 and 240 patients, respectively, from October 2003 to April 2004, with a one-year follow-up. The mean initial cost of CABG was R\$ 7,759.78 and of CA, R\$ 6,307.79. After one year, the mean total costs were R\$ 7,875.73 for CABG and R\$ 8,234.96 RVM for CA. CABG has a 23.0% higher cost than the CA²⁷. This finding was similar in the SRJ, where mean total costs of CA accounted for 71% of expenses paid by SUS for CABG (Tables 2 and 3).

The average length of stay was 17.5 days in the CABG in survivors and 20.8 days in deaths and in CA, it was 4.2 and 7.7 days respectively, in the SRJ from 1999 to 2008 (Tables 4 and 5). Piegas et al²⁰ observed that the differences between the length of stay means in the various regions of Brazil ranged from 10.7 to 15.5 in the Northeast and North. If we consider only the survivors in the CABG in the SRJ, the length of stay was higher than that observed on average in Brazilian hospitals.

Brown et al²⁸, studying the frequency and costs of complications associated with CABG without valve replacement in 114,223 Medicare beneficiaries in 2005, observed that the mean cost of CABG was US\$ 32,200 and the mean hospital stay of 9.9 days. Adjusting these results by comorbidities and demographic variables, the authors observed incremental cost and length of hospital stay of US\$ 15,500 and 5.3 days in the presence of any complication²⁸. We hypothesize that the same would have occurred in patients in the SRJ, where most deaths had five or more complications⁵. This fact can be corroborated by the high expenses with ICU, especially in deaths.

The MASS II study, carried out from 1995 to 2000, at the Heart Institute in Sao Paulo, involving 611 candidates to CABG due to multi-vessel coronary disease with good LV function, compared the costs of medical treatment with the performance of CA and CABG (203, 205 and 203 patients) with a one-year follow-up²⁹. The mortality rate in the first 30 days was similar in the three groups (1.9%, 4.4%, 3.9%). The mean costs in one event-free year were US\$ 2,453.50, 10,348.93 and 12,404.21, respectively.

The authors concluded that the actual costs of CA increased in one year, approaching those of the CABG, and that the medical treatment had a lower initial cost with greater increase in one year because of recurrent angina. However, the cost-effectiveness of these procedures has not been definitively established, being appropriate only in CABG³⁰ with no gain in quality-adjusted life years (QALYs)³¹.

Murad and Murad suggest that strict quality control of CABG can possibly improve performance³². Gomes et

al¹⁵ suggest that a joint technical approach of interaction between the technical skill of the surgical team and organizational aspects can improve the performance of CABG and the results depend on the structure and allocation of human and material resources.

The main limitation of this study is the absence of clinical information and the fact that expenses are reported by the HAA, allowing only a partial assessment of the economic problem. It is necessary to carry on studies to further discuss the inclusion of technology in the health system, with emphasis on cost-effectiveness for the best allocation of resources, especially considering the growing demand of the aging population. It is also necessary to investigate the reasons for the wide variability between hospitals regarding in-hospital mortality, either in the mean length

of hospitalization, or the expenses with procedures or components of these expenses.

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 study is not associated with any post-graduation program.

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