

Hospital Costs of Coronary Artery Bypass Grafting on Elective Coronary Patients

Nagib Haddad, Eliana Bittar, Andréa Fabiana de Marchi, Coralice dos Santos Veiga Kantorowitz, Andréa Cotait Ayoub, Mayuli Lurbe Fonseca, Leopoldo Soares Piegas

Instituto Dante Pazzanese de Cardiologia – São Paulo, SP - Brazil

Summary

Objective: To assess hospital costs associated with coronary artery bypass grafting performed on elective coronary patients, and the relation of costs with the number of grafts.

Methods: Descriptive prospective study carried out at Instituto Dante Pazzanese de Cardiologia in April, May and June of 2005. Coronary patients of different ages and both genders were included. Emergency patients, patients with other associated heart conditions and reoperation cases were excluded. Appropriate forms for the operating room, early postoperative period and for the final period in the ward were developed for the initial hospitalization phase preoperatively.

Results: The procedure was performed on 103 patients, at an average cost of R\$6,990.00 (US\$2,784.98), at a minimum of R\$5,438.69 (US\$2,166.81), and maximum of R\$11,778.96 (US\$4,692.81); standard deviation was R\$1,035.47 (US\$412.54) and the confidence interval was 95%, ranging from R\$6,790.33 - R\$7,190.27 (US\$2,705.31 - US\$2,864.67). The total average cost for three to five bypass grafts was higher (R\$7,148.05) than for one and two bypass grafts (R\$6,659.29) and the difference was significant ($p < 0.05$).

Conclusion: The highest average costs were in the operating room (R\$4,627.97), and in the early postoperative period (R\$1,221.39), followed by costs incurred in the ward after the early postoperative period (R\$840.04) and by the initial preoperative period in the ward (R\$300.90).

Key words: Hospital costs; coronary artery disease; health economics; costs of coronary artery bypass grafting.

Introduction

Technological progress in the area of health with the introduction of new equipment, new diagnostic methods and new therapeutic processes has led to increased expenditures, thus affecting the economy of various countries^{1,2}. This relative growth may become unsustainable in the long term, and cost control strategies have to be studied.

The first step is to assess the cost of certain medical procedures, analyzing their cost-benefit and cost-effectiveness in order to obtain the best possible result for patients and compare these indicators, so as to choose the procedures that least impact the funding allocated to the area of health.

As concerns the treatment of coronary artery disease, many papers have been published in the last decades in scientific literature, dealing with these and other economic aspects of clinical treatment procedures, of coronary artery bypass grafting, of percutaneous transluminal angioplasty and stent implantation³⁻⁹.

In Brazil very few studies have been published regarding the economic aspects of therapeutic procedures for coronary

artery disease^{2,10,11}.

The objective of this paper is to assess the average cost of coronary artery bypass grafting from initial hospitalization through discharge of patients with chronic coronary artery disease with an elective indication for this procedure and relate this cost to the number of grafts performed.

Methods

Patients - This is a descriptive, prospective study carried out at the Instituto Dante Pazzanese de Cardiologia (IDPC, Dante Pazzanese Institute of Cardiology), hospital of the São Paulo State Secretariat of Health, and included coronary artery disease patients with an elective indication for coronary artery bypass grafting.

The study was carried out with 103 consecutive patients operated in the months of April, May and June 2005, of both genders and different ages. Exclusion criteria were emergency patients, those with other associated heart conditions and reoperation patients.

For the purpose of recording data on the consumption of material, medicines, serum, blood and derivatives, use of equipment, human resources, complementary tests, etc., we developed appropriate forms for the four phases of medical care provided to patients: 1) initial stay in the ward during the preoperative period; 2) operating room; 3) early

Mailing address: Nagib Haddad •

Av. Dr. Dante Pazzanese, 500 – 13o andar

04012-909 – São Paulo, SP - Brazil

E-mail: nagihaddad27@hotmail.com

Manuscript received August 10, 2006; Revised manuscript received September 14, 2006; Accepted September 14, 2006.

postoperative room; 4) final ward stay following the early postoperative period.

The nurses in charge of each area have trained the nurse aides to fill out the forms. After such training, an assessment was carried out with a pilot sample with ten patients. On-duty nurses were in charge of supervising the forms which were completed on a daily basis. The nurses in charge of each sector were responsible for the general supervision on a weekly basis.

Direct hospital costs were calculated at average prices valid for April, May and June 2005, and were classified as follows:

- 1) Consumption material: needles, syringes, probes, lines, gloves, aprons, gauze, solutions, etc;
- 2) Medication, serums, blood and derivatives;
- 3) Surgical threads;
- 4) Perfusion material: set of tubes, crystalloid cardioplegia, hemoconcentrator, arterial line filter, pump-oxygenator [heart-lung machine], etc;
- 5) Complementary tests: laboratory tests, electrocardiogram, echocardiogram, x-rays, etc;
- 6) Specific staff: physicians, anesthesiologists, perfusionists and scrub nurses.

The use of equipment, its depreciation, indirect costs relating to water, light, gases and telephone consumption, food, laundry, cleaning, maintenance, administration, security, etc, and costs relating to personnel such as nurses, nurse aides, and other employees were estimated within the operating room rate and the daily rates of early postoperative room and wards.

Costs relating to the services provided by physicians, perfusionists and scrub nurses were estimated based on the working time during surgery; anesthesiologist-related costs were recorded per procedure performed.

To present the results in US currency, we established an average conversion rate of R\$ 2.51 reals per US dollar for the months of April, May and June 2005.

For the statistical analysis, quantitative data are presented with average values, standard deviations, minimum and maximum values, and qualitative variables were presented in percentages. Confidence intervals of 95% were calculated, and the average values were compared using Student's *t* test, with a significance level of $p < 0.05$.

The project was analyzed and approved by IDPC's Research Ethics Committee and the patients who participated in the study read and signed the informed and free consent term.

Results

Table 1 presents the average cost in reals and in percentage of initial preoperative ward care where we observed that the highest cost was associated with daily rates which accounted for 92.8% of the total cost, with no significant difference between a surgery with one or two grafts and surgeries with three to five grafts. In this phase, the average duration of hospital stay for all patients was 2.8 days, with a minimum of one day and a maximum of 12 days, standard deviation of

2.3 days. There was no difference in the average duration of hospital stay between those who received one or two grafts and those who received between three and five grafts.

In the operating room the highest average cost was the cost of perfusion material, followed by consumption material, staff, operating room rate and surgical threads.

For the patients who received from three to five grafts, the higher costs were those of threads, medication, serums, blood and derivatives, and specific staff, as compared to the cost for those who received one and two grafts (Table 2).

Table 3 shows that, in the early postoperative period, the highest costs for patients who received from three to five grafts had to do with consumption material and medication, serums, blood and derivatives. In this phase, the average duration of hospital stay was 3.2 days, with a minimum of 2 and maximum of 9 days, standard deviation of 1.04 day. The average duration of hospital stay was slightly longer for those who received from three to five grafts (3.3 days) than for those who received one or two grafts (3.0 days).

As regards costs at the final phase of ward stay, the highest costs had to do with daily rates and consumption material (Table 4). The average duration of hospital stay was 5.7 days, with a minimum of 3 days and a maximum of 32 days, standard deviation of 4.34 days. For one and two grafts, the average duration of hospital stay was 4.9 days, with a minimum of 3 days and a maximum of 10 days, standard deviation of 1.59 day. For three to five grafts, the average duration of hospital stay was 6.1 days, with a minimum of 3 days and a maximum of 32 days, standard deviation of 5.14 days.

Table 5 presents the global average costs. We observed that they were higher in the operating room (R\$4,627.97 – 66.2%), followed by the early postoperative period (R\$1,221.39 – 17.5%) and postoperative ward stay (R\$840.04 – 12.0%).

The average cost of the whole coronary artery bypass grafting procedure was R\$6,990.30, with a minimum of R\$5,438.69, and a maximum of R\$11,778.96, standard deviation of R\$1,035.47 and confidence interval of 95% from R\$6,790.33 - R\$7,190.27.

In US currency, the global average cost was US\$2,784.98, minimum of US\$2,166.81, maximum of US\$4,692.81, standard deviation of US\$412.54 and confidence interval of 95% US\$2,705.31 - US\$2,864.67.

The average total cost of the procedure was higher for surgeries involving three to five grafts (R\$7,148.05) than for surgeries involving one or two grafts (R\$6,659.29) and the difference was statistically significant ($p < 0.05$).

Discussion

The results obtained in this study reflect the costs of coronary artery bypass grafting in elective, non-emergency patients, with no other associated heart condition, throughout the hospitalization period, from the preoperative period through discharge. The study was carried out in a public hospital specialized in cardiology that serves primarily patients referred by the public health care network.

Studies on costs of medical procedures give results that cannot be generalized to other countries or even regions of the

Table 1 - Average cost, in reais and in percentage, for patients undergoing coronary artery bypass grafting, in the preoperative ward according to the number of grafts and type of cost

Type of cost	One or two grafts		Three to five grafts		Total	
	Average	%	Average	%	Average	%
Consumption material	2.43	0.8	3.10	1.0	2.89	1.0
Medication and serums	11.46	3.8	15.46	5.1	14.21	4.7
Complementary tests	3.97	1.3	4.98	1.7	4.66	1.5
Daily rates	284.58	94.1	276.68	92.2	279.14	92.8
Total	302.44	100.0	300.22	100.0	300.90	100.0

Table 2 - Average cost, in the Operating Room, in reais and in percentage, for patients undergoing coronary artery bypass grafting, according to the number of grafts and type of cost

Type of cost	One or two grafts		Three to five grafts		Total	
	Average	%	Average	%	Average	%
Threads	590.82	13.0	656.50	14.0	635.46	13.7
Medication, serums, Blood and derivatives	135.13	3.0	150.93	3.2	145.87	3.2
Perfusion material	1,363.84	30.1	1,371.82	29.4	1,369.26	29.6
Physicians, anesthesiologists, perfusionists and scrub nurses	723.81	16.0	774.07	16.6	757.97	16.4
Room rates	728.74	16.1	728.74	15.6	728.74	15.7
Total	4,532.59	100.0	4,672.92	100.0	4,627.97	100.0
TOTAL	4. 532,59	100,0	4.672,92	100,0	4.627,97	100,0

Table 3 - Average cost, in the early postoperative period, in reais and in percentage, for patients undergoing coronary artery bypass grafting, according to the number of grafts and type of cost

Type of cost	One or two grafts		Three to five grafts		Total	
	Average	%	Average	%	Average	%
Consumption material	146.16	13.3	200.40	15.7	183.02	15.0
Medication, serums, Blood and derivatives	217.01	19.7	278.44	21.8	258.76	21.2
Complementary tests	91.86	8.3	98.18	7.7	96.15	7.9
Daily rates	647.61	58.7	700.37	54.8	683.46	55.9
Total	1,102.64	100.0	1,277.39	100.0	1,221.39	100.0

same country, since they depend on the economic structure where health care is provided. Human resources, medication, equipment, complementary tests and other inputs generate higher or lower costs depending on the region or country.

With respect to the costs of myocardial revascularization, one of the first papers published in the literature was written by Kelly et al³, and compared a consecutive series of 78 patients who underwent percutaneous transluminal angioplasty with 85 patients who underwent coronary artery bypass grafting of a single vessel with a one-year follow-up. The total cost of the procedure, per patient, was 43% lower for angioplasty.

Krueger et al⁴, in a retrospective study, assessed the cost of

coronary artery bypass grafting in 50 patients who received three and four grafts, and found an average cost of 14,328.00 Canadian dollars. In a comparison with previous studies, they observed that the cost increases with the number of vessels treated and the age of patients.

Ohashi et al⁵, in Japan, studied cost-effectiveness for 313 patients who underwent angioplasty and 161 patients who underwent coronary artery bypass grafting, with a follow-up of 3 years and 10 months. They observed that the average duration of hospital stay and the initial costs were higher for surgery, but that the uneventful survival rate was worse for the group that underwent angioplasty.

Table 4 - Average cost, in the early postoperative ward stay, in reais and in percentage, for patients undergoing coronary artery bypass grafting, according to the number of grafts and type of cost

Type of cost	One or two grafts		Three to five grafts		Total	
	Average	%	Average	%	Average	%
Consumption material	136.12	18.9	207.87	23.2	184.43	22.0
Medication, serums, Blood and derivatives	87.95	12.2	69.98	7.8	75.85	9.0
Complementary tests	4.45	0.6	5.21	0.6	4.96	0.6
Daily rates	493.10	68.3	614.46	68.4	574.80	68.4
Total	721.62	100.0	897.52	100.0	840.04	100.0

Table 5 - Average total cost of coronary artery bypass grafting, in reais and in percentage, according to the number of grafts and type of medical care

Type of cost	One or two grafts		Three to five grafts		Total	
	Average	%	Average	%	Average	%
Initial preoperative ward stay	302.44	4.5	300.22	4.2	300.90	4.3
Operating room	4,532.59	68.1	4,672.92	65.4	4,627.97	66.2
Early postoperative	1,102.64	16.6	1,277.39	17.9	1,221.39	17.5
Postoperative ward stay	721.62	10.8	897.52	12.5	840.04	12.0
Total	6,659.29	100.0	7,148.05	100.0	6,990.30	100.0

Peigh et al⁶ carried out a retrospective study of the clinical records and bills of 250 patients who underwent coronary artery bypass grafting according to age bracket. The authors observed that older patients presented more complications, longer hospital stay and higher costs than younger patients.

Mauldin et al⁷ studied the association of certain preoperative factors with postoperative complications and the costs of coronary artery bypass grafting in 807 patients, and found higher costs for more severe degrees of angina, previous myocardial infarction, older age, congestive heart failure and the number of impaired vessels.

Smith et al⁸ also studied preoperative factors that might influence total cost in 604 patients who underwent coronary artery bypass grafting and observed higher costs, with statistical significance for the following characteristics: old age, lower ejection fraction, previous coronary artery bypass grafting, female patients, no previous angioplasty, severe coronary disease, black race patients and diabetes.

Henderson et al⁹, in the RITA-I study, chose 1,011 patients with coronary disease at random and had them undergo angioplasty or surgery, with a 5-year follow-up. There was no significant difference between the proportion of deaths and acute myocardial infarction in the two groups. These events were five times as frequent in the first year of follow-up than in the following years for both groups. Among those who underwent angioplasty, 26% had to undergo surgery in the follow-up period, mostly in the first year of follow-up. In the group submitted to surgery, there was a reintervention rate of 2% per year. The incidence of angina was consistently higher in the group that underwent angioplasty. The total costs in five years showed no statistically significant difference between the

two initial strategies – angioplasty or surgery. They concluded that the procedure should be chosen so as to balance the more invasive nature of the surgery and the higher risk of recurring angina and reintervention associated with angioplasty over several years.

Abizaid et al¹², in the ARTS study, conducted a draw to select 1,205 multivessel coronary disease patients to undergo stent implantation (600) or coronary artery bypass grafting (605), with 112 diabetic patients in the first group and 96 in the second group. After one year, the uneventful survival rate was lower in the group of diabetic patients who had undergone stent implantation (63.4%) than in diabetic patients who had undergone surgery (84.4%), and the costs were higher in the second group.

Reynolds et al¹³ conducted a retrospective study with multivessel coronary disease patients in which 100 underwent stenting and 200 underwent coronary artery bypass grafting. They compared the clinical and economic results over a two year follow-up. There was no statistically significant difference in the mortality rates and in the incidence of acute myocardial infarction. The initial cost of stent implantation was 43% lower than the surgery and was even 27% lower after two years. They concluded that, despite repeated revascularizations, the cost of stenting was significantly lower than the cost of grafting for multivessel coronary disease patients.

Yock et al¹⁴ analyzed the cost-effectiveness of coronary artery bypass grafting and of angioplasty with stenting in multivessel coronary artery disease patients of the BARI study considering the quality of life index and concluded that the surgery provides better results than angioplasty and at a lower cost.

In Brazil, Bittar & Castilho² evaluated only the direct costs of the material used in the operating room in patients undergoing coronary artery bypass grafting. The items associated with perfusion material, threads and consumption material were the ones that accounted for the higher average cost. They also observed a statistically significant difference between the costs of materials according to the number of grafts. These findings are similar to our findings in this study as regards the operating room.

Favarato et al¹⁰, in Brazil, in the MASS II study, analyzed the cost-effectiveness of clinical treatment procedures, angioplasty with stenting and coronary artery bypass grafting in 611 patients with multivessel coronary artery disease and preserved left ventricular function. The patients were randomized in three groups and followed up over one year. The effective costs of angioplasty increased over the one-year period and almost reached the costs of surgery. Clinical treatment cost was lower upfront but rose higher over the year because of the high rate of angina, whereas surgery presented more stable costs.

Weintraub et al¹⁵ compared the initial costs and the costs over one year arising from myocardial revascularization surgery and angioplasty with stenting performed in 988 multivessel coronary disease patients. The average duration and the cost of initial hospital stay were higher for surgery. Over one year, reintervention was needed by 17.2% of the patients in the angioplasty group and 4.2% in the surgery group. At the end of this period, although the difference had decreased, the costs remained higher for the surgery group.

Chee et al¹⁶ studied events and costs for 2,272 old patients, aged 75 or more, comparing them with 9,745 younger patients, aged less than 75, in five American states and four Canadian hospitals. When compared with younger patients, older patients remained for longer in hospital, with higher mortality rates and higher costs.

Zhang et al¹⁷ compared the costs and the need for new

revascularization surgery over a one-year period for 488 patients who underwent angioplasty with stenting and for 500 patients who underwent coronary artery bypass grafting. At the end of one year, total costs were higher for the group undergoing surgery, but the need for reintervention was smaller.

Almeida¹¹, in Brazil, compared the costs of coronary artery bypass grafting (86 patients) with percutaneous transluminal angioplasty (240), with a one-year follow-up. In the surgery group, reintervention reached 3.5% whereas 26.7% reinterventions were needed in the angioplasty group. The initial average cost of surgery was R\$7,759.78 and the cost of angioplasty was R\$6,307.79. At the end of one year, total average costs were R\$7,875.73 for the surgery group and R\$8,234.96 for the angioplasty group.

In view of the varied results found in the literature, more follow-up studies of at least one year are required to compare the cost-benefit ratio of the procedures currently used to treat patients with chronic coronary artery disease.

This study is a preliminary study designed to assess initial global costs, whether direct or indirect, of the initial coronary artery bypass grafting procedure in a public hospital specializing in cardiology that serves primarily patients who have been referred by the public health care network. The average total cost of the procedure was R\$6,990.30 (US\$2,784.98), minimum of R\$5,438.69 (US\$2,166.81); maximum of R\$11,778.96 (US\$4,692.81), standard deviation of R\$1,035.47 (US\$412.54) and confidence interval of 95% from R\$6,790.33 - R\$7,190.27 (US\$2,705.31 - US\$2,864.67). The total average cost was higher for three to five graft surgery (R\$7,148.05) than for one or two graft surgery (R\$6,659.29) ($p < 0.05$).

Potential Conflict of Interest

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

References

1. Whyne DK. Health care costs. *Eur Heart J*. 2002; 23: 1237-9.
2. Bittar E, Castilho V. O custo médio direto do material utilizado em cirurgia de revascularização do miocárdio. *Rev Assoc Med Bras*. 2003; 49: 255-60.
3. Kelly MA, Taylor GJ, Moses HW, Mikell FL, Dove JT, Batchelder JE, et al. Comparative cost of myocardial revascularization: percutaneous transluminal angioplasty and coronary artery bypass surgery. *J Am Coll Cardiol*. 1985; 5: 21-8.
4. Krueger H, Gonçalves JL, Caruth FM, Hayden RI. Coronary artery bypass grafting: how much does it cost? *Can Med Ass J*. 1992; 146: 13-168.
5. Ohashi H, Tsutsumi Y, Murakami A, Ueyama K, Fukahara K, Yamashita A, et al. Comparison of long-term clinical results and cost-effectiveness of percutaneous coronary angioplasty and coronary artery bypass grafting. *Nippon Kyobu Geka Gakkai Zasshi*. 1994; 42: 222-7.
6. Peigh PS, Swartz MT, Vaca KJ, Lohmann DP, Naunheim KS. Effect of advancing age on cost and outcome of coronary artery bypass grafting. *Ann Thorac Surg*. 1994; 58: 1362-6.
7. Mauldin PD, Weintraub WS, Becker ER. Predicting hospital costs for first-time coronary artery bypass grafting from preoperative and postoperative variables. *Am J Cardiol*. 1994; 74: 772-5.
8. Smith LR, Milano CA, Molter BS, Elbeery JR, Sabiston DC, Smith PK. Preoperative determinants of postoperative costs associated with coronary artery bypass graft surgery. *Circulation*. 1994; 90: 124-5.
9. Henderson RA, Pocock SJ, Sharp SJ, Nanchahal K, Sculpher MJ, Buxton MJ, et al. Long-term results of RITA-1 trial: clinical and cost comparisons of coronary angioplasty and coronary artery bypass grafting. *Randomised Intervention Treatment of Angina*. *Lancet*. 1998; 352: 1419-25.
10. Favarato D, Hueb W, Gersh BJ, Soares PR, Cesar LAM, Da Luz PL, et al. Relative cost comparison of treatments for coronary artery disease: the first year follow-up of MASS II study. *Circulation*. 2003; 108 (Suppl II): II21-II23.
11. Almeida RMS. Revascularização do miocárdio – estudo comparativo do custo da cirurgia convencional e da angioplastia transluminal percutânea. *Rev Bras Cir Cardiovasc*. 2005; 20: 142-8.
12. Abizaid A, Costa MA, Centemero M, Abizaid AS, Legrand VMG, Limet RV, et al., on behalf of the ARTS Investigators. Clinical and economic impact of diabetes mellitus on percutaneous and surgical treatment of multivessel coronary disease patients. Insights from the Arterial Revascularization Therapy Study (ARTS) trial. *Circulation*. 2001; 104: 533-8.
13. Reynolds MR, Neil N, Ho KK, Berezin R, Cosgrove RS, Lager RA, et al. Clinical and economic outcomes of multivessel coronary stenting compared with bypass

- surgery: a single-center US experience. *Am Heart J.* 2003; 145: 334-42.
14. Yock CA, Boothroyd DB, Garber AM, Hlatky MA. Cost-effectiveness of bypass surgery versus stenting in patients with multivessel coronary artery disease. *Am J Med.* 2003; 115: 382-9.
 15. Weintraub WS, Mahoney EM, Zhang Z, Chu H, Hutton J, Buxton M, et al. One year comparison of costs of coronary surgery versus percutaneous coronary intervention in the stent or surgery trial. *Heart.* 2004; 90: 782-8.
 16. Chee JH, Filion KB, Haider S, Pilote L, Eisenberg MJ. Impact of age on hospital course and cost of coronary artery bypass grafting. *Am J Cardiol.* 2004; 93: 768-71.
 17. Zhang Z, Spertus JA, Mahoney EM, Booth J, Nugara F, Stables RH, et al. The impact of acute coronary syndrome on clinical, economic, and cardiac-specific health status after coronary artery bypass surgery versus stent-assisted percutaneous coronary intervention: 1-year results from the Stent or Surgery (SoS) trial. *Am Heart J.* 2005; 150: 175-81.