

# Myocardial revascularization: comparative cost study between conventional coronary bypass and percutaneous transluminal coronary angioplasty

*Revascularização do miocárdio: estudo comparativo do custo da cirurgia convencional e da angioplastia transluminal percutânea*

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## *Abstract*

**Objective:** To compare the costs of coronary bypass surgery (CBS) and percutaneous transluminal coronary angioplasty (PTA) over a one-year follow up.

**Method:** Eight-six patients were submitted to 87 CBS and 240 patients to 267 PTA, between October 2003 and April 2004. The mean age of the two groups was 62 years. The CBS group was submitted to a mean of 3.7 bypasses/patient, using 96.5% of arterial conduits. In the PTA group, a mean of 1.1 angioplasties / procedure were performed. Twenty-one (24.4%) patients had an angioplasty performed before the CBS. Each group was subdivided in, Subgroup A and B, in respect to the manner of payment.

**Results:** The mean cost for CBS was R\$ 7.759,78, per procedure; in the PTA group the cost/angioplasty was R\$

6.307,79. At the end of a year, the end values were R\$ 7.875,73 for the CBS and R\$ 8.234,96 for the PTA group. In Subgroup B the CBS patients had a mean hospital cost of R\$ 11.061,63 and R\$ 11.087,29 at the end of a year; in the PTA group hospital costs were R\$ 11.110,83, and at the end of a year R\$ 13.414,59.

**Conclusions:** The author concludes that: 1) only 26.4% of the 326 patients were submitted to CBS; 2) PTA group presented 26.7% re-interventions and CBS group only 3.5%; 3) CBS costs were 17.4% lower than those of the PTA Group after one year, for subgroup B.

**Descriptors:** Myocardial revascularization. Costs and cost analysis. Coronary artery bypass. Angioplasty, transluminal, percutaneous coronary.

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### Resumo

**Objetivo:** Comparar custos da cirurgia de revascularização do miocárdio (CRM) e da angioplastia transluminal percutânea (ATP), com seguimento por um ano.

**Método:** Oitenta e seis pacientes foram submetidos a 87 CRM e 240 pacientes, a 267 ATP, no período de outubro de 2003 a abril de 2004. A idade média dos dois grupos foi de 62 anos. No grupo da CRM foram confeccionados 3,7 enxertos/paciente, com o uso de condutos arteriais em 96,5% dos pacientes. No grupo da ATP, foram realizadas 1,1 angioplastias, por procedimento. Vinte e um (24,4%) pacientes haviam sido submetidos a angioplastias previamente à CRM. Cada grupo foi dividido em dois subgrupos, conforme o custo, pago como um todo ou individualmente.

**Resultados:** No grupo da CRM, o custo médio da cirurgia foi de R\$ 7.759,78 por procedimento, no grupo da ATP, foi de

R\$ 6.307,79. Ao fim de um ano, os valores foram R\$ 7.875,73, para o grupo da CRM e R\$ 8.234,96, para o da ATP. No subgrupo B de pacientes pertencentes ao grupo da cirurgia, o custo médio por procedimento foi de R\$ 11.061,63 e, no grupo da angioplastia, de R\$ 11.110,83 e, ao final de um ano, R\$ 11.087,29 e R\$ 13.414,59, respectivamente.

**Conclusões:** Conclui-se que: 1) dos 326 pacientes submetidos a tratamento, apenas 26,4% foram alocados para o grupo da cirurgia; 2) o grupo da angioplastia apresentou um índice de 26,7% de reintervenção, enquanto no grupo da CRM foi de 3,5%; 3) no primeiro ano, a CRM foi 17,4% mais econômica do que a ATP, no subgrupo B de pacientes.

**Descritores:** Revascularização miocárdica. Custos e análise de custo. Ponte de artéria coronária. Angioplastia transluminal percutânea coronária.

## INTRODUCTION

In the 1990s, several scientific works compared coronary artery bypass grafting (CABG) with percutaneous transluminal angioplasty (PTA), in patients suffering from coronary arterial disease involving multiple arteries [1-6]. The results of all showed that in respect to death, strokes and acute myocardial infarction, differences between these two types of treatment were non-existent, but there were a greater number of re-interventions in the PTA group. King III [7] speculated that cardiac mortality in the PTA group may be greater than the reported mortality. More recently, since the year 2000, a comparison has been made between CABG and PTA [8-11], with the use of intracoronary stents, whether conventional (CIS) or coated with drugs (DCIS). In these studies, the comparisons were the same, with the exception of mortality which was variable among the different studies and of the reduction of the number of re-interventions for restenosis. Cost analysis in these works demonstrated that the PTA procedure has a lower cost, both because of the hospital stay and because of the patient's evolution during the first year. In subsequent years there was a progressive reduction of the differences between the groups [12].

With the improvement of technology in the treatment of coronary injuries and with the cost being so important both for public institutions and private health companies, the physician must make his decision for the best treatment of his patient based not only on clinical results, but also on the costs of the procedures [13,14].

The goal of this study was to compare the costs of two

procedures, CABG and PTA, in a defined period of time, in a tertiary reference hospital for cardiology and the evolution of these costs over a period of one year.

## METHOD

From October 2003 to April 2004, 326 patients were submitted to 354 coronary revascularization procedures in the Policlínica Hospital in Cascavel, Brazil. These patients were divided into two groups where one group of patients were submitted to CABG and the other group to PTA.

All patients who were submitted to the coronary revascularization in this period were included in the study, independently of any association with other heart diseases, there was no randomization of patients but they were placed in either one of the groups according to the primary decision of the hemodynamics staff or on the clinical assessment of the patient. No patient who was referred for surgery was rejected from the study, independently of the variables such as ejection fraction, number of vessels involved, gender, age, association with other heart diseases, etc.

In order to assess the costs of the procedures, the two groups were split into two subgroups. Subgroup A included patients for whom payment of the material used (hospital and ICU rates, pharmacy, implants, prostheses, complementary laboratorial examinations and administrative expenses) was made as a total and Subgroup B for whom payment of this material was individually for the items used. Only the hospital procedure costs were analyzed and not costs related to clinical hospitalization during the first year nor day-to-day medications.

The costs were subdivided into hospital costs (including hospital rates and medications used in the hospital), laboratorial costs (including radiological, blood and electrocardiographic examinations) and materials (operative material, implants and prostheses). The costs are represented in Brazilian national currency: Reals (R\$).

The costs of coronary cineangiographic studies before the study procedures were excluded, as they had been performed both in the PTA group and in the CABG group.

Variables such as mortality, acute myocardial infarction, strokes and angina were not analyzed in the groups and doctor's fees were not included as this was not the purpose of the study.

Group 1 or the CABG Group included 86 patients who were submitted to 87 surgical procedures. The mean age was 61.8 years, varying from 39 to 79, with a median of 63 years. Men made up 62.8% (54 patients) of the group.

Twenty-one (24.4%) patients had previously been submitted to PTA, 11 patients had been submitted to one angioplasty, six patients to two angioplasties, three patients to three angioplasties and one patient to five angioplasties. One patient had been submitted to CABG previously. The mean time between the coronary cineangiography and the surgery was  $66 \pm 51.3$  days. Other procedures were associated in eight patients (9.3%). As associated procedures, three patients were submitted to valvuloplasties, three patients to valve replacement and two patients to the aneurysmectomy. Three hundred and nineteen coronary artery bypass grafts were performed with a mean of  $3.67 \pm 1.12$  grafts/patient (median of 4 grafts, varying from one to seven grafts). Only three (3.5%) patients had only one graft. From the 86 patients, the left internal thoracic artery was employed in 83 (96.5%) cases; the anterior interventricular coronary artery in 77 (92.8%) cases and its diagonal branches in six cases.

The saphenous vein was used as a graft in 236 cases, with 89 anastomoses to the marginal branches of the circumflex artery, 66 to the diagonal branches, 50 to the right coronary artery, 11 to the posterior descending branch, seven to the anterior interventricular artery and 13 to the diagonal, marginal and posterior ventricular branches. The mean time of hospital stay was  $9.40 \pm 4.15$  days, of which  $2.90 \pm 2.55$  days was in the ICU.

From the patients submitted to CABG, 63.9% (56 patients) belonged to Subgroup A and 36.1% (31 patients) to Subgroup B, with 32 procedures performed in this group (Table 1).

Table 1. Demographic data

	CABG	PTA
Patients	86	240
Procedures	87	267
Gender - men	62.8%	60.5%
Age		
Mean	61.8	61.8
Median	63	62
Prior procedures		
PTA	24.4%	8.2%
CABG	0%	0.8%
Time from cineangiography to procedure	$66 \pm 51.3$ days	$25 \pm 51.2$ days
Associated procedures	9.3%	0%
Arteries treated	319	303
Revascularizations / patient	$3.67 \pm 1.12$	$1.16 \pm 1.00$
Use of LITA	95.4%	
N° of stents		313
N° balloons		326
Use of stents	84.64%	
Revascularization of 1 vessel	3.5%	85.8%
Subgroup A	63.9%	71.6%
Subgroup B	34.1%	28.4%

Group 2 or the PTA Group included 240 patients representing 73.6% of the patients submitted to coronary revascularization, performing a total of 267 angioplasties (75.2% of the total procedures). In this group, 162 patients (60.5%) were men. The ages varied from 37 to 85 years, with a mean of 61.8 years and a median of 62 years.

The patients of this group had been submitted to 22 angioplasties previously, where 11 (50%) patients had been submitted to one angioplasty, four (18.2%) to two angioplasties and one patient (4.6%) to three angioplasties. In this sample, 8.2% of the angioplasties were not primary. The mean time between the coronary cineangiography and PTA was  $25 \pm 51.2$  days and in 111 cases it was performed very soon after the coronary cineangiography or even on the same day. The number of arteries with lesions requiring treatment (lesion greater than 50%) was  $2.77 \pm 1.70$ , with 302 vessels treated, with a mean of 1.16 vessels/patient. The anterior interventricular coronary artery was treated in 170 (56.1%) cases, the right coronary artery in 53 (17.5%), the circumflex artery and the diagonal branches in 25 cases each and the marginal branches of the circumflex artery in 15 cases. In one case a saphenous graft to the right coronary artery was necessary. Three hundred and thirteen intracoronary stents and 326 angioplasty balloons were used, with a final mean of  $1.17 \pm 0.79$  intracoronary stents per patient. A total of 274 (87.5%) CIS and 39 (12.55) DCIS

were used. From the 267 angioplasties, 33 were performed in two vessels, one in three vessels and the rest in one vessel, except for 14 failures, in which it was not possible to treat the coronary lesions. A mean of 1.13 angioplasties were performed in each procedure. In respect to the time between the angioplasties study and previous angioplasties, 11 patients repeated the PTA in less than one year, seven between one and two years and four after more than two years. Two patients had been submitted to the CABG previously in periods that varied from 19 months to 10 years. The total time of hospital stay was of  $2.87 \pm 1.49$  days, with  $0.37 \pm 0.94$  days spent in the ICU.

In this group, 192 (71.6%) patients belonged to Subgroup A and 76 (28.4%) to Subgroup B. In Subgroup B, the mean numbers of intracoronary stents and of balloons were  $1.71 \pm 0.93$  and  $1.23 \pm 1.04$ , respectively with 39 DCIS used, giving 29.5% of the total number of stents (Table 1).

## RESULTS

In Group A, during the initial period of hospitalization, one patient was submitted to a new CABG, because of acute ischemia in the immediate postoperative period, with a new graft performed in the affected region. This procedure represents 1.6% of the re-intervention rate in this group.

In Group 2, in the same period, 24 (10%) patients were submitted to new procedures with new angioplasties performed in 22 (9.2%) patients and CABG in two (0.8%) patients. Of the re-interventions with new angioplasties, 22 patients were submitted to a single new angioplasty, two to double angioplasties, and one patient to three angioplasties.

In Group 2, there was a re-intervention rate of 26.7%, while in Group 1 it was 3.5%. In the PTA Group, there were 25 re-interventions in the first six months and 37 in the first year, with two patients passing to the surgery group.

The costs in Group 1, with laboratory, hospital and material were R\$  $336,48 \pm 77,86$ , R\$  $1022,42 \pm 652,33$  and R\$  $6973,09 \pm 1797,98$  respectively, resulting in a total in the primary period of treatment of R\$  $7759,78 \pm 2458,80$  per procedure, as is illustrated in Table 2.

Table 2. Costs (R\$) per procedure from hospitalization until the end of the first year

	CABG	PTA
Laboratory	$336.48 \pm 77.86$	$170.23 \pm 34.01$
Hospital	$1.026.42 \pm 652.33$	$648.64 \pm 456.54$
Material	$6.973.09 \pm 1.797.98$	$5.216.00 \pm 5.336.05$
TOTAL	$7.759.78 \pm 2.264.40$	$6.307.79 \pm 5.289.57$

To calculate the cost per patient, a total of R\$  $7.850,01 \pm 2.359,55$  was obtained, which did change by the end of the first year due to new procedures, except for the two (2.3%) patients who moved to Group 2, thus increasing the costs to R\$  $7875,73 \pm 2464,40$  (Table 3).

Table 3. Costs (R\$) per patient (initial procedure and follow up for 1 year)

	CABG	PTA
Initial procedure	$7.850.01 \pm 2.359.55$	$6.988.30 \pm 5.854.99$
follow up for 1 year	$7.875.73 \pm 2.464.40$	$8.234.96 \pm 6.885.37$
With re-allocation	$7.875.73 \pm 2.464.40$	$8.245.63 \pm 6.863.39$

In respect to Group 2 the costs including laboratory, hospital and material were R\$  $170,23 \pm 34,01$ , R\$  $648,64 \pm 456,54$  and R\$  $5216,00 \pm 5336,05$  respectively at the end of the primary hospitalization giving a total cost of R\$  $6307,79 \pm 5289,57$ , per procedure, as seen in Table 2. When the final result is analyzed in respect to the number of patients and not to procedures a cost of R\$  $6988,30 \pm 5854,99$  was seen in the hospital period and R\$  $8234,96 \pm 6932,27$  by the end of a year. When the costs of the two patients who were reallocated to the surgical group were included, the value obtained was R\$  $8245,63 \pm 6863,39$  as seen in Table 3.

When we analyze Subgroup B, both in the CABG group and in the PTA group, the results per procedure of laboratorial, hospital and material costs are detailed in Table 4. The hospital costs and the costs at the end of one year per patient, were R\$  $11061,63 \pm 2529,48$  and R\$  $11087,29 \pm 2518,92$  respectively for Group 1 and R\$  $11160,83 \pm 8402,38$  and R\$  $13414,59 \pm 12642,24$  for Group 2. When the costs of the patients who changed groups are considered, the value of Group 1 did not alter but Group 2 increased to R\$  $13557,63 \pm 12560,78$  (Table 5).

Table 4. Costs (R\$), per procedure, of hospitalization for subgroup B

	CABG	PTA
Laboratory	$402.36 \pm 13.14$	$191.43 \pm 18.46$
Hospital	$1.665.87 \pm 750.63$	$725.85 \pm 540.94$
Material	$8.636.57 \pm 1.573.46$	$10.030.36 \pm 7.778.74$
TOTAL	$10.302.44 \pm 2.084.69$	$11.014.30 \pm 7.711.70$

Table 5. Costs (R\$), per patient, in subgroup B (Initial procedure and follow up for 1 year)

	CABG	PTA
Cost patient initial	11.061.63 ± 2.529.48	11.160.83 ± 8.402.38
Cost patient at the end of 1 year	11.087.29 ± 2.518.92	13.414.59 ± 12.642.24
Cost patient at the end of 1 year with reallocation	1.087.29 ± 2.518.92	13.557.63 ± 12.560.78

### COMMENTS

Worldwide publications denominate CABG as the standard invasive procedure in the treatment of coronary insufficiency when a favorable result is not obtained by clinical treatment. Over the two last decades, several works have demonstrated that PTA has similar results to CABG in respect to mortality, acute myocardial infarction and strokes. But, independently of the use of balloons, CIS and, over the last years, DCIS, the number of re-interventions has been the greatest obstacle of the PTA procedure [15-17]. Another point considered has been the cost of these procedures [18], which has been unfavorable in respect to the CABG over the first years [19], with the exception of some groups [17,20,21].

Several works on DCIS have demonstrated that this difference has diminished in absolute numbers [17]. Based on these works and with the goal of understanding the reality in Brazil, we completed this study considering only administrative data with the clinical data excluded, which may give a biased result.

In this work, a true sample of consecutive patients treated by PTA or CABG was analyzed, in a government-authorized tertiary cardiology service over a period of six months. The medical fees were not analyzed, individually or as a part of the total costs, for ethical reasons.

The two groups were homogenous in relation to the gender and age. The proportion of patients submitted to the PTA as well as the number of procedures performed in this group were greater than in the CABG group.

When the initial sample of 354 procedures in 326 patients was analyzed in the Cardiovascular Surgery and Invasive Cardiology Service of the Associação Pró-Vita de Cascavel, it was seen that the number of patients submitted to PTA represent 73.6% of the total number of patients treated. In a work by Mack et al. [22], in which 7% of patients treated in the United States of America were analyzed in a period

immediately before ours, the frequency of PTA was 65.4%. The patients who participated in this study were allocated to each of the groups according to the decision of the clinician or of the hemodynamic staff, with all cases allocated to surgery accepted and included in the CABG Group. The sample of patients was homogenous in both groups in respect to the age, gender, as well as in respect to worldwide publications.

The patients in Group 1 had undergone a greater percentage of previous procedures, 21 patients had been submitted to 37 angioplasties, representing 24.4% of all the cases. In Group 2, the number of patients previously submitted to interventions was 18 (7.5%), with PTA having been performed in 88.9% of the cases.

The difference in time between the coronary cineangiography and the procedure in the CABG (66 ± 51.3 days) and PTA groups (25 ± 51.2 days), was due to the fact that all patients in the first group stay for a period in the ICU, unlike those in the PTA group, who enter the ICU only if there are complications. In spite of this, the literature also presents a shorter interval for patients who undergo PTA [9].

One of the aspects that can be considered a bias in Group 2 is the association of coronary artery bypass grafting with other procedures in 9.35% of the cases, however the main reason for the indication of treatment was coronary arterial disease. This association characterizes Group 2 as being a group in which the costs of initial treatment are greater, but this does not represent a significant increase

The point which differentiates the samples of the study is the number of treated arteries. In Group 1, the mean number was 3.67 ± 1.12, and in only 3.45% a single vessel was treated and in Group 2 only 34 (12.7%) angioplasties were performed in more than one vessel giving a total of 87.3% of the cases in which only one vessel was treated. Mack et al. [22] reported percentages of from 14.9 to 17.2 of angioplasties in multiple vessels and a mean of 3.38 grafts per patients. Van Domburg et al. [11] performed angioplasties in more than one vessel in 31% of his cases, without mentioning the number of grafts per surgery. The study of Bari [23] treated an average of 3.1 coronary arteries per patient in the CABG Group and 1.9 in the PTA Group. The internal thoracic artery was utilized in 95.4 % of the patients, similar to the work of Serruys et al. [9], who presented a result of 93% of the surgical patients who were submitted to at least one arterial graft.

When the two groups were compared, we observed that patients who were submitted to CABG were more severely ill and with higher risks, taking into account the number of vessels treated and the associated diseases,

as PTA is the first choice in patients with single arterial lesions. In Group 1 only 3.5% of the procedures were surgeries involving a single vessel.

In the study group, 111 patients were submitted to PTA, soon after the coronary cineangiography or at least within six to eight hours of the examination representing 41.6% of the angioplasties. This demonstrates a high rate of self-generated procedures. The use of intracoronary stents in 84.6% of the patients was comparable to the percentage (89%) reported by Serrus et al. [9] in the ARTS study.

As the form of payment of the two procedures was different when compared to international publications, a division of the groups into two subgroups was necessary. In Group A, the payment authority re-charges the costs of the two procedures in the form of a fixed payment, in which only the implants and prostheses are paid for nominally using a pre-established value. The other expenses such as hospitalization, laboratory, medication and administrative costs are paid for as a predetermined value. In Subgroup B all the costs were real, as the expense corresponds to a cost that must be paid by the payment authority. This last subgroup corresponds more to reality, with more representative numbers, which also includes the most recent technology. Take note that DCIS were only used in this second group, as the first payment authority does not authorize its use and even limits the utilization of CIS. There was a difference between the two groups in respect to their subgroups, as, in the CABG Group, the percentage of patients in Subgroup A was less (64.4%) than in Subgroup A of the PTA Group (71.6%).

When comparing the costs of the procedures as a whole, it is noted that there were no significant differences between the values of the hospital stays in the two groups. These values did not change either by the end of one year of follow up, with the necessity of new procedures. The CABG Group, when compared in respect to the number of procedures, gave a 23.0% higher cost than the PTA Group, during hospitalization. But, the cost must not be calculated in respect of the number of procedures performed and not in numbers of patients. Considering the group of patients for each procedure, the hospitalization costs of Group 1 were 12.3% greater than those of Group 2, thereby corroborating with other published works. However, the percentage increase in respect to CABG of the present sample, is less than the increases reported by Favarato et al. (35.9%) [10], in the ARTS study (65.4%) [9] and Weintraub et al. (88.5%) [24].

When we consider the cost per patient during the first year after the procedure, the cost is greater in Group 2, with a percentage of 4.5%, which increased to 4.7%, when the angioplasty patients who were submitted to the CABG are re-allocated to Group 2. These results are different to some previously published works, but agree with the study of Yock et al. [21].

The results are different when the true costs, as seen in Subgroup B of both the analyzed groups are considered. Comparing the hospital costs per patient at the end of one year and including the re-allocation of two patients between the groups, the costs in Group 2 were 0.9%, 17.4% and 18.2% higher. The low incidence of new procedures is responsible for the stability of the costs in the CABG Group.

With the problems that arise from the payment of highly-complex medical treatment, in general, and of cardiology in particular, including technological improvements which are common today, for example, the increase in the costs when intracoronary ultrasound is considered a compulsory cost in PTA, we should remember that:

- 1) The treatment must be initiated after discussion among the clinical, the interventionist and cardiovascular surgery groups;
- 2) The decision, as well as the optimization of the conditions of the patient, must be made considering not only the speed of recovery, but also the improvement in the long-term quality of life;
- 3) Effort should be made so that the patient can choose the treatment after an explanation of the merits of each procedure, without influence of the personal interests of physicians;
- 4) New studies must be performed in patients treated by the different methods, focusing on multicentric, prospective studies and those using DCIS.

## CONCLUSIONS

The patients who underwent CABG had a greater number of coronary arteries treated than the patients who underwent PTA, as well as fewer re-interventions. Group 1 has a higher cost than Group 2, both when considering the number of procedures and the number of patients, in respect to the costs of the first hospitalization, but by the end of one year this result is inverted. In the case of Subgroup B, in which the expenses are paid at the real cost, the values are greater in all analyses for the PTA Group.

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