

Analysis of transit time flow of the right internal thoracic artery anastomosed to the left anterior descending artery compared to the left internal thoracic artery

Análise da medida de fluxo por tempo de trânsito da artéria torácica interna direita anastomosada para a artéria interventricular anterior comparada com a artéria torácica interna esquerda

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Abstract

Introduction: We evaluated with transit time flow the performance of the right and left thoracic arteries when used as a graft for the left anterior descending artery.

Methods: Fifty patients undergoing surgery for myocardial revascularization without cardiopulmonary bypass were divided into two groups. In group A patients received graft of right internal mammary artery to the anterior interventricular branch. In group B patients received graft of left internal mammary artery to the same branch. At the end of the operation the flow was assessed by measuring transit time.

Results: In group A, mean age was 60.6±9.49 years. The average height and weight of the group was 80.4±10.32 kg and 169.2±6.86 cm. The average number of grafts per patient in this group was 3.28±1.49. The mean flow and distal resistance obtained in right internal thoracic artery was 42.1±23.4 ml/min and 2.8±0.9 respectively. In group B, the mean age was 59.8±9.7 years. The average height and weight of this group was 77.7±14.22 kg and 166.0±8.2 cm. The average number of grafts per patient in this group was 3.08±0.82. The mean flow and distal resistance

observed in this group was 34.2±19.1 ml/min and 2.0±0.7. There were no deaths in this series.

Conclusion: Right internal mammary artery presented a similar behavior to left internal mammary artery when anastomosed to the anterior interventricular branch of the left coronary artery. There was no statistical difference between the measured flow obtained between both arteries.

Descriptors: Mammary Arteries. Coronary Artery Bypass, off-Pump. Internal Mammary-Coronary Artery Anastomosis.

Resumo

Introdução: Avaliamos por meio da medida de fluxo por tempo de trânsito o desempenho das artérias torácicas direita e esquerda quando utilizadas como enxerto para revascularização da artéria interventricular anterior.

Métodos: Cinquenta pacientes submetidos à operação para revascularização do miocárdio sem circulação extracorpórea foram divididos em dois grupos. No grupo A, os pacientes rece-

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Abbreviations. acronyms & symbols

AHA	American Heart Association
NYHA	New York Heart Association
PI	Pulsatility Index
STS	Society for Thoracic Surgery

beram enxerto de artéria torácica interna direita para o ramo interventricular anterior. No grupo B. os pacientes receberam enxerto de artéria torácica interna esquerda para o mesmo ramo. Ao término da operação. o fluxo foi avaliado por meio da medida de fluxo por tempo de trânsito.

Resultados: No grupo A. idade média foi de 60.6±9.49 anos. A média de peso e altura do grupo foi de 80.4±10.32 Kg e 169.2±6.86 cm. A média de pontes por paciente neste grupo foi de 3.28±1.49.

O fluxo médio e a resistência distal obtidos na artéria torácica interna direita foi de 42.1±23.4 ml/min e 2.8±0.9 respectivamente. No grupo B. a idade média foi de 59.8±9.7 anos. A média de peso e altura deste grupo foi de 77.7±14.2215.7 Kg e 166.0±8.2 cm. A média de pontes por paciente neste grupo foi de 3.08±0.82. O fluxo médio e a resistência distal observados neste grupo foi de 34.2±19.1ml/min e 2.0±0.7. Não houve óbitos nesta série.

Conclusão: A artéria torácica interna direita apresentou um comportamento similar ao da artéria torácica interna esquerda quando anastomosada ao ramo interventricular anterior da coronária esquerda. Não houve diferença estatística entre a medida de fluxo obtida entre ambas as artérias.

Descritores: Revascularização Miocárdica. Anastomose de Artéria Torácica Interna-Coronária. Artéria Torácica Interna.

INTRODUCTION

The first reports of experimental work for a possible myocardial revascularization are from the mid 50's. A group of researchers from the Soviet Union made the anastomosis of the left internal thoracic artery to the anterior interventricular branch in dogs^[1]. This work served as the basis for the reports of the first cases in humans^[2]. In 1967. when this study was presented at a cardiology symposium in Leningrad. the majority of those present agreed to a resolution that said coronary surgery was impossible and had no future. After more than 40 years after these initial reports. the surgeries for myocardial revascularization have become one of the most performed surgeries in the world and certainly the most studied.

Several studies^[3-6] show that even after so much time passed and the steady advance of medicine in the last decades it remains the treatment of choice for patients with severe coronary disease. Obtaining consistent long-term results after performing this type of procedure depends mainly on the grafts to be used. The superiority of arterial grafts over saphenous vein grafts. especially the internal thoracic artery is well documented^[7-9]. Studies comparing these two types of grafts show a higher patency rate of 90% in 10 years for the internal thoracic artery versus 50% of saphenous vein grafts. being reflected this difference in increased patient survival. Furthermore. several studies from different groups were presented showing that the use of both internal thoracic arteries has a significant survival when a period of 20 years after surgery is evaluated^[10-13].

Most authors agree that the use of both thoracic arteries is beneficial. They also believe that the right internal thoracic artery should be used mainly in the left coronary system. especially in the circumflex artery and its branches. by making a retro-aortic^[14] passage.

The use of the right internal thoracic artery to the anterior interventricular branch is no consensus. In the last joint guideline from the American Heart Association (AHA) and the Society for Thoracic Surgery (STS)^[15]. when the best distribution of grafts according to the coronary vessels was assessed. the use of the left internal thoracic artery to the anterior interventricular branch received recommendation IB by keeping as the main graft for this branch. while the use of the right internal thoracic artery to the same branch was IIA class. In the present study we assessed fifty patients divided into two groups of twenty-five comparing them by measuring the flow for traffic time and the behavior of both thoracic arteries grafted to the anterior interventricular branch of the left coronary. Our main aim was to determine whether the flow obtained at the anastomosis of the right internal thoracic artery to the anterior interventricular branch is similar to the data obtained with the "gold standard" which is the anastomosis of the left internal thoracic artery to the same branch of the left coronary artery.

METHODS

In this retrospective study. we assessed 50 patients undergoing coronary artery bypass grafting without cardiopulmo-

nary bypass. divided into two groups of 25 patients each. In group A. there are patients who received graft of right internal thoracic artery to the anterior interventricular branch. In group B. patients who received left internal thoracic artery to the same branch. In this study. we excluded all patients who required a procedure associated with revascularization. as well as patients who possibly undergoing cardiopulmonary bypass. In none of the fifty patients conversion to cardiopulmonary bypass was required.

In both groups. we used general anesthesia. and the approach was median sternotomy. The manner on which the anesthesia was performed and how the grafts were obtained have been subject to previous publication^[16]. In both groups. the internal thoracic artery was obtained using skeletonization.

The strategy of revascularization differs somewhat between groups. In both cases. we used a dose of 2 mg/kg of heparin. The initial approach was the same. with the pericardium opened widely. pulled in its anterior edge on both sides. With the help of a polyester tape 90 cm long and 3 cm wide. a section by Lima^[17] was performed. This was applied between the inferior vena cava and the left inferior pulmonary vein to better exposure of the heart without significant changes of hemodynamics. In all fifty patients a suction tissue stabilizer (Octopuss II ®. Medtronic) to perform anastomosis was used.

Moreover. in most cases. it was performed with an intraluminal shunt. The strategy of revascularization. on which graft would be directed to coronary branch was decided at the time of operation. Rather. we chose the retroaortic right internal thoracic artery to the circumflex artery and its branches and the left internal thoracic artery to the anterior interventricular branch. The anastomoses are also preferably performed in the middle third of the coronary artery and. if the graft did not reach the target artery satisfactorily we reversed the distribution.

In group A. the operation started by anastomosis of the right internal thoracic artery to the anterior interventricular branch. followed. in cases where it was necessary. through the sidewall and finally through the anterior interventricular branch. In group B. the operation started by the anastomoses of the inferior wall. followed by sidewall and finally the anterior interventricular branch. The approach taken in group B. leaving the anterior interventricular artery last is due to a fear of injury by traction. This could occur while performing an anastomosis in the sidewall of an increased ventricle with the anastomosis of the left internal thoracic artery already performed to the anterior interventricular branch.

At the end of the anastomoses after heparin reversal. systolic blood pressure was maintained around 110 mmHg and a heart rate average ranging between 80 and 100 beats per minute. No patient in the series needed use of vasoactive drugs to obtain the desired pressure. Moreover. with “3mm probe”

(Figure 1) connected to the flowmeter Medistim brand. model Butterfly Flowmeter. flow measures by transit time and review of the pulsatility index. PI (Figure 2) were performed. To obtain these values. the patients were kept under apnea for a period of around 10 seconds. and the “probe” applied to the selected graft. According to the device manufacturer. flows higher than 10 ml/min. and a pulsatility index which measures the distal strength below 5 means an anastomosis of good quality.

After evaluation of the anastomoses. the revision of hemostasis and closure of the chest were performed. Next. still under general anesthesia. patients were referred to the intensive care unit.

This study received a favorable opinion from the Research Ethics Committee of our institution under number 20827713.2.0000.0020.

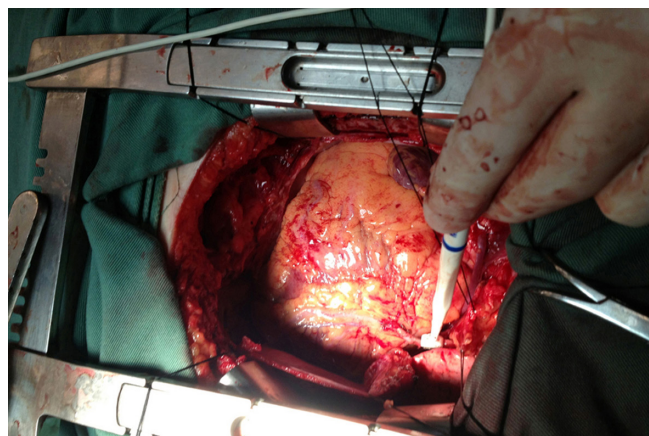


Fig. 1 - 3 mm Probe

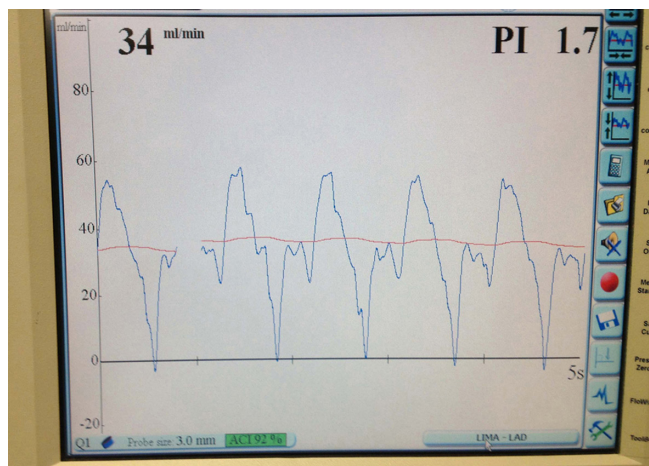


Fig. 2 - Flow analysis of internal thoracic artery

Statistical Analysis

To evaluate the association between two dichotomous qualitative variables we considered the Fisher exact test. The correlation between quantitative variables was evaluated by estimating the Pearson correlation coefficient. To compare the two groups with respect to quantitative variables we used the Student's t test for independent samples. These comparisons, considering more than two groups were performed using a model of analysis of variance factor (ANOVA). For multivariate analysis a model of Multiple Linear Regression was adjusted. *P* values <0.05 were considered statistically significant. Data were analyzed using the SPSS v.20.0 software.

RESULTS

We assessed 50 patients undergoing coronary artery bypass grafting without cardiopulmonary bypass were divided into two groups of 25 each. In group A we put patients who received internal thoracic artery to the anterior interventricular branch. In group B we put patients who received a graft of the left internal thoracic artery graft to the same coronary branch.

In group A, the mean age was 60.6 ± 9.49 ranging between 44 and 82 years and in group B 59.8 ± 9.7 between 43 and 80 years. Patients in group A had a mean weight of 80.4 ± 10.32 kg. The mean weight from B group was 77.7 ± 15.7 kg. The average height of the group A was 169.2 ± 6.86 cm and in group B 166.0 ± 8.2 cm. Table 1 shows the values of age, weight, height and body mass index for both groups:

In assessing risk factors for coronary disease, in group A 21 (84%) patients were hypertensive, compared with 18 (72%) in group B (*P*=0.496). 10 (40%) patients in group A were diabetics against five (20%) in group B (*P*=0.217) and 6 (24%) patients in group A were smokers against seven (28%) in group B (*P*=1).

In group A, seven (28%) had undergone previous coronary angioplasty and eight (32%) had presented myocardial infarction against four (16%) who had undergone angioplasty in group B and four (16%) with history of myocardial infarction. There was no statistical difference between the groups regarding previous coronary angioplasty or old myocardial infarction. Regarding the left ventricular function, if normal, moderate or poor compromise. Table 2 presents the data from both groups.

There was no statistical difference between the groups when evaluating left ventricular function (*P*: 0.461).

In the assessment of functional class, no patient in group A (0%) were in NYHA class I, 15 (60%) in class II, seven (28%) in class III, and three (12%) in class IV. In group B, three (12%) were in class I, 14 (56%) in class II, seven (28%) in class III and one (4%) in class IV. There was no statistical difference (*P*=0.258) between the two groups.

Table 3 presents the distribution of the number of individual grafts per patient in each group.

The central point of this study is the evaluation of coronary flow. The evaluation of the measured flow through the transit time showed an average flow of 42.2 ± 23.4 ml/min in Group A and 34.2 ± 19.1 ml/min in group B, featuring a statistically significant difference in favor of group A. We tested the null hypothesis that the mean FLOW is the same in both groups (RLL and LLL), versus the alternative hypothesis of means that are not all the same. Table 4 and Figure 3 shows the results obtained.

Finally, we assessed the pulsatility index, PI, that determines the resistance after the anastomosis. The device manufacturer provides measurement values for flow traffic time of less than 5 as indicative of a good quality anastomosis. In group A, the mean PI was 2.8 ± 0.9 and in group B 2.0 ± 0.7 . Table 5 shows the results obtained from both groups.

Figure 4 shows a representation of the behavior of pulsatility index in both groups.

Table 1. Quantitative variables.

	Group	n	Mean	Median	Minimum	Maximum	Standard deviation	<i>P</i> * value
Weight	B	25	77.7	79.0	43.0	115.0	15.7	0.485
	A	25	80.4	80.0	55.0	94.0	10.32	
Height	B	25	166.0	165.0	153.0	180.0	8.2	0.131
	A	25	169.2	170.0	159.0	180.0	6.86	
BMI	B	25	28.1	27.3	17.9	47.0	5.3	0.945
	A	25	28.1	28.2	20.2	34.5	3.31	
Age	B	25	59.8	59.0	43.0	80.0	9.7	0.759
	A	25	60.6	61.0	44.0	82.0	9.49	

BMI – Body Mass Index

Table 2. Left ventricular function.

	Group	
	B	A
LV Normal	12 48.00%	13 52.00%
Moderate	8 32.00%	10 40.00%
Poor	5 20.00%	2 8.00%
Total	25	25

Table 3. Individual grafts.

Number of grafts	Group	
	B	A
1	3 12.00%	0 0.00%
2	6 24.00%	8 32.00%
3	12 48.00%	13 52.00%
4	4 16.00%	3 12.00%
6	0 0.00%	1 4.00%
Total	25	25

Table 4. Flow measurement.

Group	Flow						P-Value*
	n	Mean	Median	Minimum	Maximum	Standard deviation	
B	25	34.2	31.0	13.0	82.0	19.1	0.197
A	25	42.2	34.0	16.0	94.0	23.4	

Table 5. Pulsatility index.

Group	PI						P-Value*
	n	Mean	Median	Minimum	Maximum	Standard deviation	
B	25	2.0	2.0	1.0	3.8	0.7	0.003
A	25	2.8	2.9	1.3	4.3	0.9	

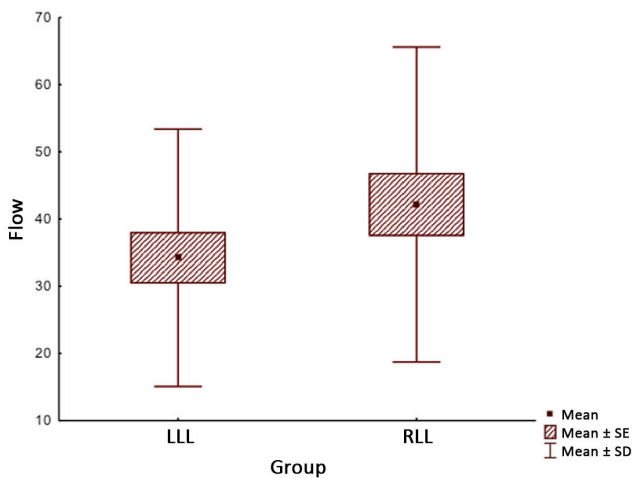


Fig. 3 - Flow Performance

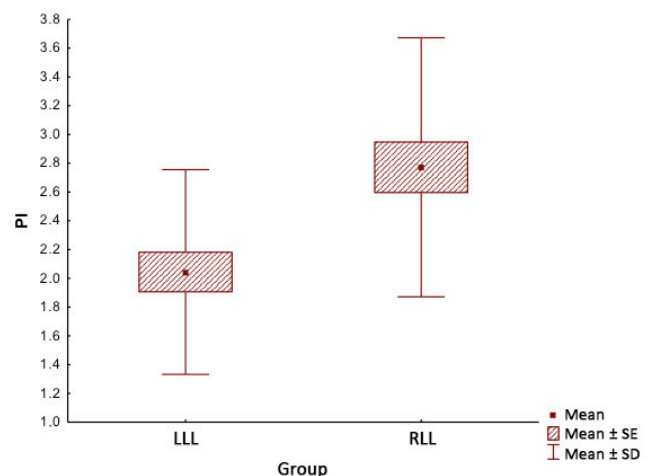


Fig. 4 - Pulsatility index

DISCUSSION

During the past 20 years, numerous studies have been published related to the prevention, diagnosis and surgical treatment of coronary artery disease^[18,19]. In these studies, the advantage on the use of the thoracic artery is clearly demonstrated due to its superior patency, showing consistent long-term results and thus leading to an increased survival. This mainly occurs in groups where getting better results over the years is less frequent as in women and diabetics.

Currently, the most widely used strategy in coronary artery bypass operations is the use of an internal thoracic artery accompanied the other saphenous vein grafts^[20,21]. However, atherosclerosis of saphenous vein is responsible for the failure of CABG during the study. A growing number of diabetics has been referred for surgery due to poor results with coronary angioplasty. There was a reduction in mortality, 5.8% vs. 20.6%, with respect to results obtained in patients who received at least one internal thoracic artery^[22].

The left internal thoracic artery presents patency greater than 90% after 10 years of its implantation. This is because less than 1% of them develops atherosclerosis with severe impairment^[23].

As already emphasized above, the use of the mammary artery improves survival of patients. Studies show that when using both internal thoracic arteries, the survival increases significantly in 20 years^[11-13]. Study presented by Ribeiro et al.^[24] shows very little difference from the histological point of view between left and right internal thoracic arteries, noting only that the distal segment of the elastic layer is more prominent.

With these results clearly established, the central focus revolves around what is the best distribution for thoracic arteries, which vessel should receive the second thoracic artery, and especially if it is appropriate to use the right internal thoracic artery to the anterior interventricular branch of left coronary. As noted earlier, our main distribution is the same advocated by Gerola et al.^[14] with the right internal thoracic artery directed to the circumflex artery and its branches through a retroaortic course.

The flow measurement by transit time became available for clinical use in the late 90s^[25,26]. It is a quick, simple and objective way to verify the quality of the anastomosis in coronary surgeries. Flows below 10 ml/min associated with a pulsatility index greater than 5 indicate problems. The pulsatility index, PI, is a number obtained by dividing the difference between the maximum flow and minimum flow by mean flow^[26].

One of the first studies on the flow measurement by transit time was published in 1998 by Walpoth et al.^[25]. In this study, the authors assessed 46 anastomoses of the left internal thoracic artery to the anterior interventricu-

lar branch. Of these, 43 had normal PI flow and, in the other three after anastomosis is performed again the PI flow has been normalized. Based on these data, the authors concluded that the measured flow by transit time is simple, reproducible and easy to perform. Moreover, they concluded that a low flow in the graft with a high PI indicates need for revision of the anastomosis and after that the values tend to normalize. They also confirmed that this type of flow measurement is cost-effective and probably prevents hemodynamic instability in the immediate post-operative period.

Leong et al.^[27] assessed 116 patients with a total of 322 grafts, with 125 arterial and 197 venous. They performed the measurement of flow by transit time. The average flow for the internal thoracic artery to the anterior interventricular branch was 37.4 ± 23.5 ml/min and 21.2 to 36 ml/min in the other grafts. In six patients the anastomosis error was detected and that being performed again. The authors found no statistical difference between PI flow or arterial and venous grafts. They concluded stating that this type of coronary flowmetry provides important and reliable information about the patency of each graft individually. It is able to accurately detect folds, twists and significant stenoses in grafts, allowing their immediate correction.

In our country, Cerqueira Neto et al.^[28] published a study showing the measured flow of the left internal thoracic artery to the anterior interventricular branch in patients who underwent surgery with and without cardiopulmonary bypass, concluding that there is no difference in flow between these two situations.

In our series, we assessed two groups of 25 patients each, comparing the performance of the left internal thoracic artery to the right internal thoracic artery, when grafted to the anterior interventricular branch. Many surgeons still have some fear of putting the right internal thoracic artery to the anterior interventricular branch. The two groups were similar with respect to weight, height and age. In the group in which the right internal thoracic artery was used there were more diabetic patients, but without statistical difference.

When evaluating flow, the group of left internal thoracic artery had an average flow of 34.2 ± 19.1 versus 42.2 ± 23.4 ml/min in the right thoracic artery group. Despite the increase, there was no significant difference between the two groups. In assessing the pulsatility index, PI, the first group had a mean PI of 2.0 ± 0.7 vs. 2.8 ± 0.9 in the second group. Despite the difference between the groups is significant ($P=0.003$), the values obtained in the group in which the thoracic artery was used showed values within the normal range, or that is, a PI below 5.

In this present series, despite the use of two internal thoracic arteries in most patients, there were no cases of mediastinitis. There was no mortality.

CONCLUSION

The results obtained in our study suggest that the right internal thoracic artery when anastomosed to the anterior interventricular branch presents an initial behavior very similar to that of the left internal thoracic artery. In cases where the left internal thoracic artery needs to be anastomosed to another coronary branch or that it is not available, the right internal thoracic artery should be considered as the substitute of choice. The initial flow obtained when comparing the right and left arteries showed no significant difference.

Authors' roles & responsibilities	
RM	Analysis and interpretation of data; final approval of the manuscript; conception and design of the study; implementation of operations and/or experiments; writing of the manuscript or revising it critically for its content
DM	Analysis and interpretation of data; conception and design of the study; writing of the manuscript or revising it critically for its content
AS	Analysis and interpretation of data; conception and design of the study; writing of the manuscript or revising it critically for its content
RJ	Help in operations and data collection; performing operations and experiments
TL	Help in operations and data collection; performing operations and experiments
GM	Help in operations and data collection; performing operations and experiments
VHS	Help in operations and data collection; performing operations and experiments
PRB	Writing and revision of the article; analysis and interpretation of data

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