

Analysis of coronary vascular resistance and blood flow of venous graft in coronary artery bypass grafting

Análise da resistência vascular coronariana e do fluxo sanguíneo dos enxertos venosos em revascularização do miocárdio

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Abstract

Objective: The aim of this study was to assess the coronary vascular resistance (CVR) and to analyze the flow differences through grafts in coronary artery bypass graft surgery.

Methods: Between 17 June and 15 July 2005, we assessed the coronary vascular resistance profile in 10 patients undergoing coronary artery bypass graft surgery by grafting a section of saphenous vein and checking CVR direct (preoperative) and indirect arterial pressure and blood flow during blood cardioplegic infusion.

Results: Significant differences between segments of coronary grafts with flow changes ranging from 36.52 to 100 ml/min were verified.

Conclusion: Despite various factors that contribute to success or unsuccess of coronary grafts, the CVR preoperative assessment can be a possible method to estimate blood flow through the coronary graft implant during surgical procedure.

Descriptors: Vascular resistance. Graft occlusion, vascular. Myocardial revascularization

Resumo

Objetivo: O trabalho tem por objetivo avaliar a resistência vascular coronariana (RVC) e analisar as diferenças de fluxo através dos enxertos em cirurgia de revascularização miocárdica.

Métodos: Foi avaliado o perfil da RVC em dez pacientes submetidos, entre 17 de junho e 15 de julho de 2005, a cirurgia de revascularização miocárdica com enxerto de veia safena por meio da aferição direta da pressão arterial (per-operatória) e indireta da RVC e do fluxo sanguíneo durante a infusão cardioplégica sanguínea.

Resultados: Foram constatadas significativas diferenças entre segmentos de enxertos coronarianos com variações de fluxo de 36,52 a 100 ml/min.

Conclusão: Conclui-se, assim, que, apesar de inúmeros fatores contribuírem para o sucesso ou insucesso dos enxertos coronarianos, possivelmente pode-se compreender melhor os resultados clínicos das cirurgias por meio da interpretação adequada da RVC.

Descritores: Resistência vascular. Oclusão de enxerto vascular. Revascularização miocárdica.

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INTRODUCTION

Circulatory system diseases are among the most important causes of morbidity and mortality of the contemporary world, including Brazil [1]. Also, due to the great social and economic impact, such diseases are among the most studied and scientifically researched diseases. Initially, the CABG procedures have brought high hopes for cardiology, however, over time, it can be noted that other factors avoided a success more lasting than the expected [2].

The combination of anatomical, histological, biochemical and/or other factors, either physiological and/or pathological ones involved in the etiopathogenic process and surgical results [3-10], does not allow that objective conclusions are obtained concerning the patency of a certain graft, even if very well performed and, even today, despite advances in cardiovascular surgery, we can not do it.

Many surgical procedures are peroperatively tested regarding objective results, such as during valvuloplasty or valve replacement, in which the performance of peroperative echocardiogram can verify the surgical “*status quo*”, and thus assume results. In CABG surgery, this has been tried with the assessment of coronary artery caliber [11,12], but it has not been fully achieved.

Despite this, various medical publications have studied late results of patients undergoing coronary artery bypass grafting, which are sometimes generically considered for future surgeries, as we could expect the same results for all cases, without considering the differences between them. Thus, we have studied herein the coronary vascular resistance (CVR), assessing the possible behavior of blood flow in coronary grafts.

METHODS

This study was based on data obtained retrospectively from the perfusion record of cardiopulmonary bypass surgery, according acceptable and widely used technical standards for coronary perfusion using antegrade cardioplegic normothermic solution, when 10 patients consecutively underwent CABG, from June 17 to July 15 in our institution. 33 coronary anastomoses were performed with a mean of 0.9 grafts of the left internal thoracic artery and 2.4 of saphenous vein grafts.

The study was developed based on the peroperative assessment of the perfusion pressure of coronary segments in patients undergoing CABG with saphenous vein, when the distal anastomosis of the graft had already been performed, by means of direct measurement and, in-line through pressure transducers when the selective infusion of cardioplegia was performed (Figure 1).

Then, by means of mathematical calculations, the CVR and the blood flow resulting from such calculations were determined for appropriate conditions of blood pressure. For demonstrative technical reasons, the arteries revascularized with the left internal thoracic artery were not included in the study. For verification reasons, all cases had their coronary artery caliber measured by dilators that were introduced inside the vessels lumens, as shown in Table 1. However, it was not our target search.

During the surgery, and with the aortic root clamped, the saphenous vein grafting with the distal anastomoses already performed underwent, alone, perfusion with normothermic blood cardioplegic solution with predetermined flow (as described below), using Braile ECO-001 heart lung machine (Braile Biomédica, São José do Rio Preto-SP, Brazil) and measuring in-line the resulting pressure continuously. After knowing the blood flow and pressure, the CVR was obtained by the equation $PVR (CVR) = BP.80/CGO$ (PVR - peripheral vascular resistance, BP - blood pressure and CGO - coronary graft output). In turn, now knowing the CVR for a particular segment of the graft/coronary, we recalculated the output for satisfactory hemodynamic conditions of $MAP = 80$ mmHg, by reversing the formula ($CGO = BP.80/CVR$) since, after surgery and with the aim to achieve good hemodynamic conditions for coronary perfusion through the graft, it will be balanced by the blood pressure.



Fig. 1 - Photo of the surgical procedure. Saphenous vein graft/coronary with distal anastomosis performed (left arrow) and undergone blood cardioplegia with flow of 100 ml/min (right arrow). “Y” catheter in connection with cardioplegia and in-line with the transducer for measuring of the blood pressure

Table 1. Relationship between the studied arteries and the results of blood pressure with blood flow of 100 ml (column 2), coronary vascular resistance (column 3) and the output adjusted to a MAP = 80 mmHg (column 4).

Artery (millimetre)	SAP/DAP/MAP (mmHg)	Resistance (dyne/s/cm ⁻⁵)	Adjusted output (millilitre)
Mg: 2.25	147/94/125	100.001	64
PD: 1.5	180/118/160	128.801	49
Mg: 1.75	106/62/77	61.601	96.25
RC: 1.75	114/65/81	64.801	100
RC: 2.5	105/74/91	72.801	87.9
Mg 1.5	145/95/125	100.001	64
Mg: 2.0	97/62/81	64.801	98.7
RC: 2.5	127/88/110	88.001	72.72
Dg: 2.0	135/81/120	96.001	66.6
Mg: 2.0	105/57/85	68.001	94.11
Dg: 1.75	145/98/114	91.201	70.17
Mg: 1.75	250/170/219	175.201	36.52
PD: 2.5	114/71/97	77.601	82.47
PV:1.25	167/110/145	116.001	55.17
Passing PV/PD	114/71/97	77.601	82.47
Dg: 1.5	217/130/176	140.801	45.45
RC: 1.25	174/100/132	105.601	60.6
DA: 1.75	219/138/184	147.201	43.4
Mg: 2.0	147/88/125	100.001	64
RPVA: 1.5	127/78/111	88.801	72.07
Dg: 1.5	234/175/202	161.601	39.6
Dg: 1.75	134/80/113	90.401	70.79
Mg: 2	145/94/125	100.001	64

Legend: DA = anterior descending artery; DA = diagonal artery; Mg = marginal artery; RCA = right coronary artery; PDA = posterior descending artery; RPVA = right ventricular posterior artery; SAP = systolic arterial pressure; DAP = diastolic arterial pressure; MAP = mean arterial pressure

The CVR was obtained in two conditions: the first with 100 ml/min and allowing coronary flow on the upstream and downstream of the anastomosis and considering both retrograde and antegrade flows, and another with flow of 50 ml/min allowing flow only the downstream of the graft's anastomosis (by clamping of the coronary artery using "bulldog" forceps on the upstream of the anastomosis) and therefore considering only antegrade flow.

Statistical data were obtained simply by the arithmetic mean of the flows and coronary resistances.

Some factors that are involved with the coronary flow, such as the flow competition and vasomotricity, as well as factors such as age, gender or medical conditions, among others were not considered in this study because the aim was to determine the CVR related exclusively to the coronary bed, accepting as persistent the physiological or pathological changes.

RESULTS

The arteries studied with flow of 100 ml (without proximal clamping) and the resulting CGO for adjusted conditions of MAP 80 mmHg are shown in Table 1. It was noted great variability of the CVR and CGO (Table 1) as well as the inverse proportionality between them (Figure 2), indicating a close relationship with the distal bed of the artery studied.

In our study, we found a mean of 68.95 ml of output corrected by the graft for MAP 80 mmHg, mode of 64 ml and median of 66.6 ml (Table 1).

The upstream clamping of the coronary arteries was necessary to simulate cases of total coronary occlusion or competitive flow (which clearly reduces the flow capacity through the graft/coronary), which was noticed with larger increase of CVR and CGO (Figure 3).

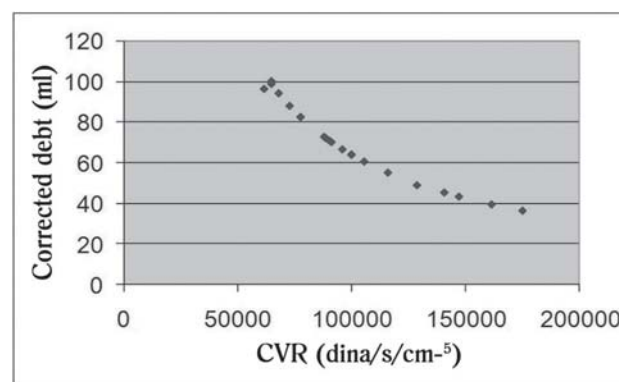


Fig. 2 - Study of cases. Blood flow (100 ml/min) by coronary graft without proximal clamping of the coronary artery in relation to the anastomosis. CVR = coronary vascular resistance

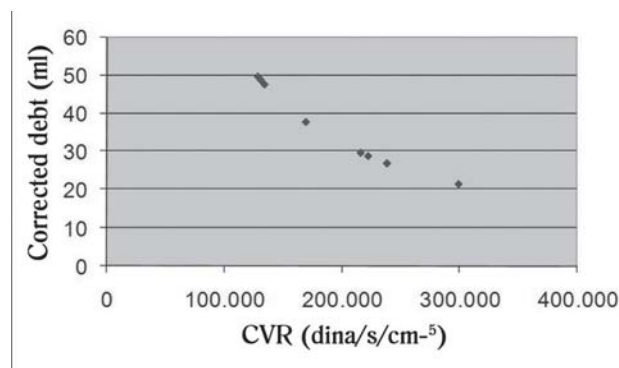


Fig. 3 - Study of cases. Blood flow (50 ml/min) through the coronary graft with proximal clamping of the coronary artery in relation to the coronary anastomosis. CVR = coronary vascular resistance

The arterial caliber, which is often used to establish the “graft/coronary quality”, did not meet the required proportionality with the output through the graft and it has shown to be ineffective as a method of assessment (Figure 4).

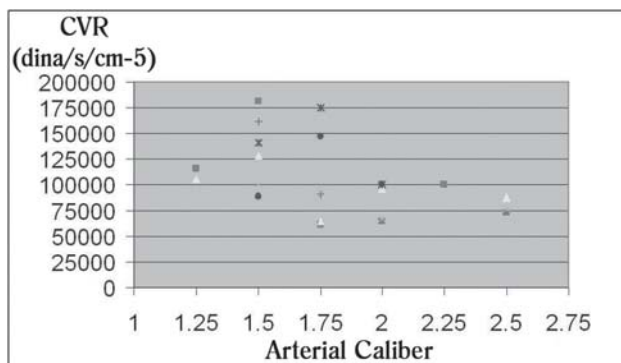


Fig. 4 - Study of cases. Relationship between arterial caliber and CVR. Note that the variability of the CVR is not directly proportional to the caliber. CVR = coronary vascular resistance

DISCUSSION

The PVR, often evaluated in various clinical situations, is indeed the mean derived from the resistance of all arteries of a body. Due to physiological or pathological conditions, the vascular resistance estimated in arteries or isolated segments may be very different from the mean expected.

There are many factors that directly or indirectly affect the CVR and may be cause of occlusion of arteries and grafts [3]. Slow coronary flow or lack of blood flow have been observed in cases of myocardial infarction or after angioplasty, suggesting mechanisms of recent onset, as the factors of post-reperfusional injury by free radicals, alpha-adrenergic vasoconstriction, angiotensin, neutrophil activation, embolic or thrombotic factors and lack of distal bed [4-10].

The different results found in CABG, even if when considering randomized studies, have maintained a permanent doubt among surgeons in respect to the reason of a well-performed procedure does not result in the expected purpose sometimes. However, it is important to question whether these excellent results are due only to the quality of the graft or the favourable conditions of the native artery, or if such results may be due to the flow and resistance. Therefore, we included the question whether we could understand better the patency of venous grafts by estimating the risk preoperatively.

In 1906, Carrel [13] noticed the changes suffered by veins when undergone process of arterialization and Faulkner et al. [14] analyzed - as effects of turbulent flow in

venous grafts - the endothelial proliferation occurred in distal portions of the anastomoses, which seems to be a variable also dependent on the CVR. Spray & Roberts [15] mention as one of the predictors of early occlusion of venous grafts, increased caliber of the grafts in relation to the coronary segments, also considering changes in blood flow.

Questions about sequential grafts and their possible benefits have been presented by several authors, as Rabelo et al. [16]. In this study we perform a sequential venous graft in one case and observed distribution of resistance by both revascularized segments, thus reducing the final resistance, which allowed not only a reasonable output, but, perhaps, and the most important: the higher velocity flow [16] and may indicate, if confirmed in future studies, possible reduction of obstructive complications [17].

Castro Neto et al. [18], assessing the postoperative flowmetry through the guide catheter, found arterial flow found in the control group, similar to values found in this study.

CONCLUSION

It is concluded that despite numerous factors contributing to the success or unsucess of coronary grafts, it can possibly be better understood the surgery clinical outcomes through the proper interpretation of the CVR.

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