# Validation of Doppler Flow Guidewire for Peak Aortic Flow Measurement in Order to Establish Its Sensitivity for Recognition of Cardiac Assistance in Demand Dynamic Cardiomyoplasty

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**Abstract**

INTRODUCTION: there are no certain data regarding the real cardiac assistance of cardiomyoplasty. We tested the use of doppler flow wire for measurement of aortic flow velocity (directly related with cardiac output) in order to demonstrate that this method is able to measure systolic assistance during stimulated beats in cardiomyoplasty.

METHOD: the technique has been tested in five coronaropathic patients (M/F = 4/1; age = 61±7.1; atrial fibrillation / sinus rhythm = 1/4; VTD = 76.6±8.26 ml/ mq; EF = 67.4±8.56). The measures were performed during a normal cardiac left catheterization for coronarography using a Flex™ Doppler flow wire of .018 inch through a 4F introducer femoral arterial access. Stimulated beats were obtained with a right ventricle stimulator catheter through a femoral venous access.

RESULTS: fourth series of measures, composed by 10 normal beats and 1 stimulated beat, were recorded: we measured the maximal peak velocity of beat n°9 (normal) and beat n°1 (post-stimulated beat) of the subsequent series. The values respectively for normal beats and for post-stimulated beats were: - first series: 50.4±13.5 and 63.4±17.5 cm/s (P = 0.0091); - second series: 65.4±15.4 and 75.2±14.4 cm/s (P = 0.0044); - third series: 49.8±8.43 and 62.4±17.7 cm/s (P = 0.0249); - fourth series: 56.8±15.4 and 63.4±13.3 cm/s (P = 0.0024). No complications were observed after the procedure.

DISCUSSION: Statistical analysis showed a significant increasing in peak flow velocity after the stimulated beats. Therefore the technique is safe and effective and may be sensitive enough to detect a similar phenomenon related to a real systolic improvement owe to latissimus dorsi graft contraction. In the first two demand dynamic cardiomyoplasty operated patients tested with this method, it has been showed an increase of 10% in aortic flow velocity between stimulated and no-stimulated beats.

**Key words**: intravascular ultrasound, heart failure.

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Nowadays there are no certain data about the real cardiac assistance that dynamic cardiomyoplasty (DCMP) and its recent development, demand dynamic cardiomyoplasty (DDCMP), could offer. After the initial enthusiasm due to the early experience in which the cardiomyoplasty seemed to be a feasible alternative to heart transplant [4, 6, 9, 10, 16], this technique lost part of its consideration not only for a discreet mortality and morbidity [13, 14, 18] but also for the poor proofs of a true cardiac assistance and the absence of direct evidence of systolic enhancement during latissimus dorsi contraction in human. Actually, for the lack of organs in Europe, the DCMP is subject of further investigations. Following this increase of interest, we tried to found a simple, repeatable and tangible method to reveal and measure every real cardiac assistance made by latissimus dorsi in cardiomyoplasty operated patients. The main reasons of the difficult measurement of an eventual cardiac assistance *in vivo* in human are:- the instability of the ascending aorta during stimulated beat that makes impossible the measurement by transthoracic echocardiography of aortic flow velocity that may be related with cardiac function; - the relative impossibility to measure it, beat by beat, during the normal stimulation protocol. In the last years, the Interventional Cardiology has proposed an intravascular method to measure blood flow velocity, the Doppler flow guide wire [24]. We describe here a test of sensitivity and feasibility of the use of Doppler Flow wire in non-heart failure patients in order to establish if its use in DDCMP operated patients could reveal positive or negative change, directly related with the cardiac output, in aortic flow velocity.

## Method

The technique has been tested in five coronaropathic patients (see Table I for clinical and functional data) with no aortic valve stenosis and reflow or aortic ectasia and aneurysm showed by transthoracic echocardiography. The measurements were performed during a normal cardiac left catheterization for coronarography, in order to study the stability of the flow velocity wave and the repeatability of data. After the obtainment of consent, through a 5F introducer femoral arterial access a Flex™ Doppler flow wire of .018 inch was advanced under fluoroscopy control into a coronary 4F Judking Right catheter and positioned in thoracic aorta just below the istmic portion, that is a fix tract of aorta. Stimulated beats were obtained with a right ventricle stimulator catheter through a femoral venous access. The flow wire was then connected with its digital display and a registration of flow velocity, during normal beats and after stimulated beats, was finally performed. The data, expressed in cm/s and calculated as media±SD, were analysed with T test and a value of $P<0.05$ was considered significant.

## Results

Fourth series of measures, composed by 10 normal beats and 1 stimulated beat, were recorded: we measured the maximal peak velocity of beat n° 9 (normal) and beat n° 1 (post-stimulated beat) of the subsequent series. The values respectively for normal beats and for post-stimulated beats were: - first series: 50.4±13.5 and 63.4±17.5 cm/s (P = 0.0091); - second series: 65.4±15.4 and 75.2±14.4 cm/s (P = 0.0044); - third series: 49.8±8.43 and 62.4±17.7 cm/s (P = 0.0249); - fourth series: 56.8±15.4 and 63.4±13.3 cm/s (P = 0.0024). The fluoroscopy time was in all patients < 1 minute. No complications were observed during and after the procedure.

## Discussion

In these last 10 years, dynamic cardiomyoplasty underwent to many investigations: firstly, in order to establish its feasibility in alternative to heart transplant, secondly to prove its effects on cardiac function.

This feasibility in alternative to heart transplant was rejected by great part of the Authors and the technique has actually few indications. Nowadays there is a new interest in the technique, due to the cost of the mechanic assistance and the lack of organs in Europe: the vascular delay [1, 12] and the demand stimulation protocol [2, 7] are giving to cardiomyoplasty new dignity.

About the effects of DCMP, two main hypothesis were made to explain the improvement of symptoms in patients who respond to DCMP: an enhanced systolic contraction and a limited heart dilatation [3, 15, 17, 19, 20]. If many Authors agree with the second hypothesis that may explain the improvement in NIHA class in some patients, as for the first one there is more perplexity.

In fact, measurements in dynamic cardiomyoplasty, as ejection fraction [6, 21], P/V loops [5, 22], stroke volume and peak oxygen consumption [25] were recorded before and after the intervention or during periods with myostimulator turned on and off: these periods were relatively long and variable in time and they are dependent by many physical factors and environment. There are no data until now in DDCMP, about beat to beat analysis of changes in cardiac function during stimulated and non stimulated beat: the analysis about this variant of cardiomyoplasty could be more independent and so more accepted by the Cardiologist community.

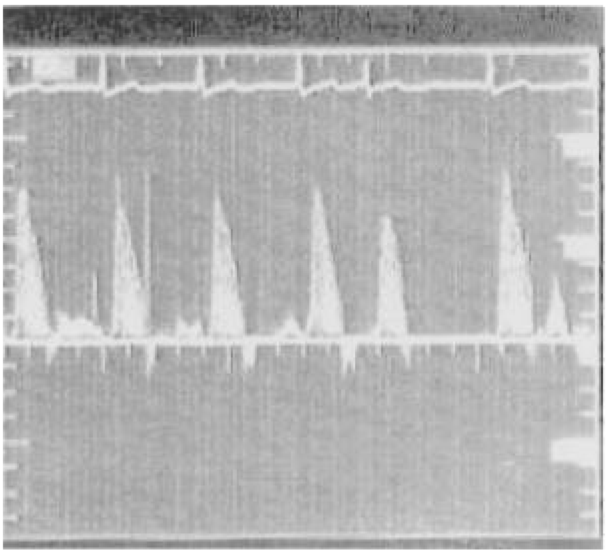

*Figure 1. Aortic flow velocity spectrum during normal (N), extrastimulated (EXTRA) and post-extrastimulated (POST-EXTRA) beats: the aortic flow velocity peak increases after the extra-stimulated beat reflexing the increase of the cardiac output due to the longer diastolic filling time.*

Measurement of aortic peak flow velocity by Doppler echocardiography could be the most direct method: it was proposed and it is really used to measure cardiac output in normal patients. Unfortunately in cardiomyoplasty operated patients, the instability of ascending aorta during the latissimus dorsi contraction makes difficult and not sensitive this measure.

Interventional Cardiology helps us giving an intravascular method for recording aortic peak flow velocity, the Doppler Flow Guide Wire. This intravascular guide wire usually used for the calculation of the coronary reserve and the evaluation of the coronary stenosis, has been validated *in vitro* and *in vivo*. The qualitative registration of phasic flow is possible and the relative changes can be determinated with sufficient accuracy by intravascular Doppler wires. The limit is the unreliability of the measurement of absolute flow volume due to interindividual differences of the catheter within the vessels [11, 23]. We believe that this fact has not great importance, because our aim is to measure a difference between the aortic peak velocity of non stimulated and stimulated beat, rather than its absolute value.

As matter of the fact, aortic peak flow velocity is directly correlated with the cardiac output as showed by the simplified equation $Q = VA$, where Q is the volume flow rate, V is the flow velocity and A is the cross sectional area of a circular pipe [26]. So any change in flow velocity causes a modification of flow volume, independently by the absolute value.

Our data showed that the measure of Doppler aortic flow velocity using an intravascular wire is safe and effective. The increase of flow velocity after the extra-stimulated beat is measurable (figure 1) and the recording beat to beat is effective and sensitive enough, as proved by statistical analysis.

An eventual cardiac assistance due to DDCMP could be measurable by this method. We can anticipate that in the first two DDCMP patients tested with this method, it has been showed an increase of 10 % in aortic flow velocity between stimulated and non stimulated beats. If further investigation will continue, it may give new interesting light to DDCMP.

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