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Impact of type of intervention for aortic valve replacement on heart rate variability

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ABSTRACT

Background: It is known that coronary heart surgery leads to varying degrees of cardiac autonomic derangement, clinically detectable as depression of heart rate variability (HRV) parameters. Few studies report that also surgical replacement of the aortic valve (SAVR) may lead to HRV abnormalities, while very little is known about the autonomic effects obtained after less invasive aortic valve replacement techniques. The study aimed to evaluate HRV after SAVR and to compare it with two less invasive techniques, transapical (TaAVI) and tranfemoral (TfAVI) aortic valve implant.
Methods: Time-domain heart rate variability (HRV) parameters have been studied by 24-h Holter ECG in 129 patients after SAVR, in 63 patients after TfAVI and in 19 patients after TaAVI.
Results: All HRV parameters were significantly depressed in SAVR, while they were almost completely preserved in TfAVI patients; TaAVI cases showed a somehow intermediate behaviour [(SDNN respectively: 71.0 ± 34.9 vs 95.9 ± 29.5 ($p < 0.001$) vs 84.4 ± 32.6 ms ($p =$ ns)]. Mean heart rate during the 24-h Holter was 8% higher in SAVR patients than in both TfAVI and TaAVI patients. The reported results were not correlated with echocardiographic ejection fraction, or presence of abnormal glucose metabolism, or degree of anaemia or treatment with beta-blockers.
Conclusions: SAVR leads to profound depression of some cardiac autonomic parameters, while less invasive procedures allow better preservation of HRV. In particular TfAVI does not induce any significant deterioration of HRV parameters and seems to be the strategy of valve implant with less impact on the cardiovascular autonomic system.

1. Introduction

The cardiovascular system answers to different stressors through complex dynamic interactions between the sympathetic and parasympathetic components of the nervous system; they modulate heart rate response, cardiac contractility, venous capacitance and tone of resistance vessels [1,2].

Clinically, cardiac autonomic regulation may be evaluated by analysis of the heart rate variability (HRV). HRV represents the fluctuations in instantaneous heart rate over a period of 24 h; its study is clinically used as an indicator of the function of the cardiac autonomic nervous system, as it is known to provide a reliable and reproducible non-invasive semi-quantitative method of evaluation of the sympatho-vagal balance of the heart [3,4].

Parasympathetic activity is attenuated and sympathetic activity enhanced after a variety of physiological and pathological conditions [5]. Among these, cardiac surgery leads to varying degrees of alteration of the complex homeostatic mechanism that modulates sympathetic and parasympathetic balance of the heart, and usually leads to depression of HRV. After coronary artery by-pass surgery, it is already known that HRV shows a significant early decrease linked to the intervention [6,7], that seems to be associated with a higher long-term mortality rate [8]; after surgery, HRV recovers gradually in weeks or months [9,10].

Abbreviations: AGM, abnormal glucose metabolism; CABG, coronary artery by-pass graft; CR, cardiac rehabilitation; EF, ejection fraction; Hb, haemoglobin; HR, heart rate; HRV, heart rate variability; PCI, percutaneous coronary intervention; pNN50, proportion of successive beats with differences in normal RR intervals >50 ms; RMSSD, square root of the mean square differences of successive normal RR intervals; SAVR, surgical aortic valve replacement; SDANN, standard deviation of the 5-min average of normal RR intervals; SDNN, standard deviation of all normal RR intervals; SDNN index, average of the standard deviations of all NN intervals for each 5-minute segments; TAVI, transcatheter aortic valve implant; TaAVI, trans-apical aortic valve implant; TfAVI, trans-femoral aortic valve implant.

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Depression of HRV parameters is not exclusively related to coronary surgery. A very limited number of papers reported that HRV decreases also in patients undergoing valvular heart surgery, and that cardiovascular autonomic dysfunction seems to be more pronounced and persisting for longer period after mitral valve surgery than aortic valve surgery [11,12].

The probable reasons for HRV reduction after heart surgery include a combination of various effects, such as surgical manipulation of heart and adjacent structures, duration of anaesthesia and cardioplegia, and use of extracorporeal circulation [10,13]. In coronary artery disease, some degree of autonomic derangement has been anyway recorded also in patients submitted to elective percutaneous coronary angioplasty, with variable levels of HRV decrease depending on different localization of coronary lesions [14]. To our best knowledge, only one study — performed on a small number of patients — has made as yet a comparison of HRV after surgical aortic valve replacement (SAVR) versus tranfemoral (TfAVI) and transapical (TaAVI) aortic valve implantation: it confirmed the negative effects of surgery and a preservation of various HRV indexes after percutaneous valve implantation [15]. Anyway, in the cited study the two percutaneous approaches for aortic valve replacement have not been considered separately in spite of their different invasiveness.

Aim of our study was to evaluate HRV as an index of cardiac autonomic function early after SAVR, and to compare the HRV results separately with two different less-invasive replacement techniques, i.e. TfAVI and TaAVI, in order to possibly identify if there was any differential autonomic involvement with such less-invasive techniques.

2. Methods

We retrospectively reviewed the clinical records of 211 patients consecutively admitted for in-hospital cardiac rehabilitation within two weeks after surgical replacement of aortic valve (SAVR, 129 patients) and after transfemoral or transapical aortic valve implant (TfAVI 63 patients, and TaAVI 19 patients). Inclusion criteria were recent substitution of aortic valve and presence of stable sinus rhythm. Exclusion criteria were persistent or permanent atrial fibrillation, frequent ventricular ectopic beats, sinus sick syndrome or second or third degree atrioventricular block, cardiac pacing, graft substitution of ascending aorta, mitral valve surgery at the same time as SAVR, history of acute coronary syndrome in the previous 6 months, presence of cardiomyopathy or acute heart failure, presence of advanced renal failure; patients with diabetes have been included in the study and received separate analysis.

For all patients, a thorough clinical history was available; kind of intervention and time elapsed from it, history of diabetes or hypertension, haemoglobin (Hb) level, and medications used were registered. To control for different effects of various beta-blocker drugs on heart rate (HR), the dosages of beta-blockers used at the time of Holter recording were converted to percentage of target dosage [16]. Patients without history of diabetes underwent an oral glucose tolerance test during the second week of CR, in order to identify subclinical abnormalities of glucose metabolism (AGM); the results were also recorded.

On the day of admittance to CR, all patients were submitted to 24-h Holter recording, while beginning light training activities according to the hospital protocol; cardiac autonomic function was evaluated by time-domain HRV [17] on this Holter recording.

During hospitalization, left ventricle ejection fraction (EF) was assessed by means of a standard two-dimensional transthoracic echocardiogram (Simpson's method when good quality echo windows were available; area-length method in the other cases).

2.1. HRV evaluation

After cleansing of arrhythmias and artefacts, time-domain HRV parameters were evaluated from the 24-h Holter: mean, minimum and maximum heart rate (mean-HR, min-HR, max-HR), standard deviation of all normal RR intervals (SDNN), square root of the mean square differences of successive NN intervals (RMSSD), standard deviation of the 5-min average of NN intervals (SDANN), proportion of successive beats with differences in NN intervals >50 ms (pNN50), average of the standard deviations of all NN intervals for each 5-minute segments (SDNN index) and HRV Triangular Index.

The HRV parameters were evaluated both on the whole 24-h recording and subdivided by day and night. We defined “day” as the time period between 06:00 and 22:59 and “night” as the period between 23:00 and 05:59.

2.2. Statistical analysis

Descriptive statistics are expressed as mean ± standard deviation for continuous variables; categorical variables are presented as absolute values with percentages. Differences between groups have been evaluated by means of the Student *t* test for unpaired samples. Differences between day and night values of HRV in the individual cases were evaluated by means of the paired samples Student *t* test. The relationships between continuous variables were evaluated by Spearman's correlation coefficient. Categorical variables were compared using the Pearson chi-square test (χ^2). All reported probability values are two-tailed and the significance level was set at 0.05. All statistical analyses were performed using the SPSS 18 software package (SPSS Inc., Chicago, IL, USA).

2.3. Statement

All participants gave an informed consent to undergo the procedures described in the study. The usual diagnostic and follow-up routine for the CR had been applied; no special tests or treatment were performed. The present study is part of a larger study on the effects of CR in TAVI patients [18]; approval from the Provincial Ethics Committee was obtained for parent the study.

3. Results

3.1. Main results are reported in Table 1

Patients submitted to TfAVI and TaAVI were significantly older than patients that had undergone SAVR. There was a prevalence of females in the TfAVI group, while in the other two groups males represented about two thirds of the total, with a similar prevalence. Time elapsed from intervention to HRV study was identical among the groups.

The patients of the three groups showed substantially the same prevalence of abnormal glucose metabolism (diabetes and prediabetes). A history of hypertension was more frequent than normal blood pressure in all groups, with higher prevalence in patients submitted to TaAVI.

In the TaAVI group, a low percentage of patients (10%) had undergone also a percutaneous coronary intervention (PCI) during the month preceding the TAVI procedure, while the prevalence of recent PCI in the TfAVI group (19%) and that of concomitant coronary artery by-pass graft (CABG) in the group of patients submitted to SAVR (30%) were slightly higher and not significantly different between them.

Mean-HR, as evaluated by 24-h Holter, was on average 8% higher in the SAVR patients than in both TfAVI and TaAVI groups; the difference with SAVR was highly significant for the TfAVI group ($p = 0.000$), but not for the TaAVI patients ($p = 0.084$). Also min-HR in the SAVR group was 10–12% higher than that recorded in patients of both TfAVI and TaAVI groups, with a highly significant difference; no differences among groups have been observed for the max-HR recorded during the 24-h observation period.

All the time-domain HRV parameters analysed for the whole period of 24-h Holter recording were significantly more depressed in SAVR