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„Preserved Autonomic Regulation in Patients Undergoing Transcatheter Aortic Valve Implantation Characterized by Cardiovascular Parameters“

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Preserved Autonomic Regulation in Patients Undergoing Transcatheter Aortic Valve Implantation Characterized by Cardiovascular Parameters

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Introduction

In the past decade, alteration of cardiovascular autonomic function has been identified as a powerful predictor of fatal outcome in patients after myocardial infarction [1]. Especially the imbalance of sympathetic and parasympathetic nervous system resulting in a relative predominance of the sympathetic tone puts the patient at a higher risk of adverse cardiac events [2]. In cardiac surgery the new technology of transcatheter aortic valve implantation has been developed to minimize the operative trauma in high-risk patients with severe symptomatic aortic stenosis who are refused for conventional surgical aortic valve replacement [3]. In this study, we established both the transarterial and the transapical implantation technique by a surgical team in a hybrid suite [4]. Both procedures do not require the use of the heart-lung-machine and a cardioplegic arrest of the heart. Furthermore, time of anaesthesia is significantly shortened. Therefore, we hypothesized that the cardiovascular autonomic function is less affected compared to conventional surgery.

Materials and Methods

A total of 58 consecutive patients undergoing either transcatheter aortic valve implantation (TAVI) or surgical aortic valve replacement (SAVR) with heart-lung machine and being in stable sinus rhythm were enrolled in a prospective study. Thirty-four of them underwent surgical aortic valve replacement (SAVR) and 24 of them transcatheter aortic valve implantation (TAVI).

Heart Rate and Blood Pressure Variability

Standard methods of heart rate variability (HRV) analysis include time and frequency domain parameters [5]. Time domain parameters are based on statistical methods derived from the RR-intervals as well as the differences between them. Mean heart rate is the simplest parameter, but the standard deviation over the whole time series is the most prominent HRV measure for estimating overall HRV. Frequency domain HRV parameters enable to analyze periodic dynamics in the heart rate time series. The normalized high frequency power (0.15-0.40 Hz) reflects modulation of vagal activity by respiration whereas the normalized low frequency power (0.04-0.15 Hz) represents vagal and sympathetic activity via the baroreflex loop. The low-to-high frequency ratio is used as an index of sympathovagal balance. Heart rate variability reflects the complex interactions of many different control loops of the cardiovascular system. In relation to the complexity of the sinus node activity modulation system, a predominantly nonlinear behaviour has to be assumed. Thus the detailed description and classification of dynamic changes using time and frequency measures is often not sufficient. Therefore, a number of sophisticated nonlinear methods were calculated in this study, too [6].

For BP series all described HRV parameters can be accordingly calculated, only some statistical parameters as well as ones of symbolic dynamic need to be adapted.

Estimation of Baroreflex Sensitivity

The Dual Sequence Method [7] is based on standard sequence methods but distinguishes two kinds of BBI responses: bradycardic (an increase in systolic BP causes an increase in the following BBI) and tachycardic fluctuations (a decrease in systolic BP causes a decrease in following BBI). A baroreflex event is assumed if there are monotonic ramps of three successive values in systolic BP and BBI. The local baroreflex sensitivity (BRS) is estimated by the slope of a linear regression of these BBI values over the corresponding BP. After that, the BRS is calculated by the average of these local values.

Statistical Analysis

In order to quantify the recovery of the autonomous control of the cardiovascular system after cardiac surgery, the parameters of BBI and BP variability as well as baroreflex sensitivity was considered. For each group, Kruskal-Wallis tests compared the outcome of each parameter the day before surgery, 24h and seven days after surgery on the intensive care unit.

Results

Mean age of patients was 64±14 years (SAVR-group) and 81±7 years (TAVI), this difference is due to the current consensus on using TAVI in high-risk patients.

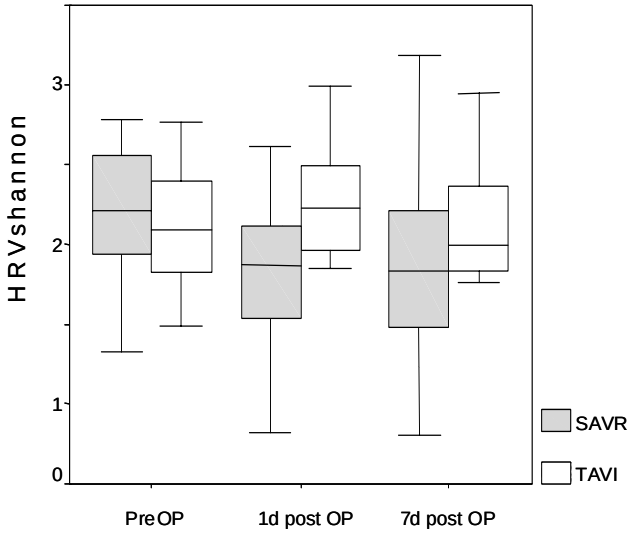

Fig. 1: Shannon entropy of the beat-to-beat intervals in SAVR (surgical aortic valve replacement) and TAVI (transcatheter aortic valve implantation). For each group pre- and post-operative state (PreOP, 1dpostOP – 1 day, 7dpostOP – 7 days) are compared by a Kruskal-Wallis test ($p<0.01$ in SAVR, n.s. in TAVI) [8].

In cardiovascular variability and baroreflex sensitivity, there were no major differences among the two groups preoperatively. At 24h after surgery, in contrast to the TAVI-group, the SAVR-group showed a depression of HRV and BRS parameters without a tendency to recover one week after surgery (cf. Fig. 1, $p<0.01$). At every time of the examination the HRV- and BRS-data of the patients undergoing TAVI represented a stable level without any significant up- and downturns.

The contrary phenomenon as in HRV was detectable in the variability of the systolic BP. The changes are best described by fwShannon, the Shannon entropy of systolic blood pressure distribution. The parameter showed a significant elevation after SAVR which continued during following week ($p<0.001$). For TAVI, no such significant changes could be observed.

Baroreflex sensitivity as well as both specifications of bradycardic and tachycardic ones show significant depression in SAVR-patients caused by surgery. This decrease was even more pronounced in tachycardic fluctuations than in bradycardic ones. For all BRS parameters, there were no alterations in patients undergoing TAVI.

Discussion

The last decade witnessed a strong increase in basic knowledge of the cardiovascular autonomic system. It has been demonstrated, that the analysis of linear and nonlinear components of heart rate and BP variability and baroreflex sensitivity can be a powerful tool to estimate a patient's risk for death or life-threatening events [3,6]. This study indicates their ability in distinguishing the recovery of autonomous control of the cardiovascular system after different cardiac surgical procedures.

The present study confirms earlier results as far as the clinical outcome is concerned. Although patients undergoing TAVI were significantly older and had more major comorbidities compared to patients with conventional surgery, the early mortality was not different between the groups, and in both groups major adverse cardiovascular events did not occur. So whatever mechanisms are responsible for this decline of autonomic function as shown in Fig. 1 in the early postoperative period, they may be related to the trauma of open surgery and to the overall higher invasiveness of a procedure with heart-lung machine. Our results affirm the hypothesis of conserved cardiovascular autonomic function in patients treated by TAVI. Almost all variability parameters of TAVI treated patients present a stable level pre- and postoperatively without any significant up- and downturns.

For the first time [8] we were able to demonstrate in this study, that in contrast to patients undergoing conventional open surgery, there are less alterations of the cardiovascular autonomic system in patients with TAVI.

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