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Comparison of Baroreflex Sensitivity to Fall and Rise in Blood Pressure Induced by the Valsalva Maneuver

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Abstract

The baroreflex plays a key role in human blood pressure (BP) regulation. Its efferent limb consists of a vagal and a sympathetic component. The Valsalva maneuver is widely used to quantify vagal baroreflex function (vagal baroreflex sensitivity, BRS_{vagal}), but most studies have focused on the R-R interval response to BP *decrement*, even though the subsequent response to an *increment* in BP is important and different. We sought to evaluate if BRS_{vagal} can be determined from the rise in BP during phase III-IV of the Valsalva maneuver (BRS_{vagal_{inc}}), to assess the association between BRS_{vagal_{inc}} and BRS_{vagal} derived from the preceeding BP decrement (BRS_{vagal_{dec}}), and to validate BRS_{vagal_{inc}} as index of autonomic function.

We studied patients with severe autonomic failure (n=49, 25 female), mild autonomic failure (n=25, 11 female), and matched normal controls (n=29, 15 female). BRS_{vagal_{inc}} and BRS_{vagal_{dec}} were calculated as the regression slope of R-R interval and systolic BP during phase III-IV and early phase II of the Valsalva maneuver, respectively, and compared with other autonomic indices across groups.

BRS_{vagal_{inc}} could be calculated in all subjects and correlated highly with BRS_{vagal_{dec}} (r=0.72, p<0.001). BRS_{vagal_{inc}} also significantly correlated with BP changes during phase II and IV of the Valsalva maneuver and sympathetic barosensitivity. BRS_{vagal_{inc}} was significantly different between groups, being highest in controls and lowest in patients with severe autonomic failure.

Vagal BRS, determined by relating R-R interval to BP increase following phase III, is a valuable autonomic index, provides additional information about vagal baroreflex function, and reflects overall severity of autonomic failure.

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AUTHOR CONTRIBUTION

Naoki Wada analyzed the data and performed statistical analysis and wrote the first draft.

James Schmelzer conceived the project.

Tonette Gehrking, James Schmelzer, and David Sletten recruited the subjects and collected clinical data.

David Sletten provided statistical and instrumental support.

Phillip Low and Wolfgang Singer designed and supervised the study including analysis of subjects, manuscript preparation.

Keywords

baroreflex sensitivity; Valsalva maneuver; blood pressure

INTRODUCTION

The maintenance of postural normotension depends on a number of variables, including the status of plasma volume, venous capacitance bed, and arterial baroreflexes, which regulate heart rate and vasomotor tone in response to arterial pressure [1]. A key role of the Autonomic Laboratory is to ascertain if orthostatic hypotension or intolerance is present and whether the etiology is neurogenic. Neurogenic OH (NOH) is due to an impairment of arterial baroreflexes [2]. The Mayo Autonomic Laboratory has evaluated sympathetic and vagal components of the baroreflex by studying dynamic alterations in blood pressure (BP) and heart rate (HR) during the Valsalva maneuver. There are four main phases of the Valsalva maneuver. Phase I is a transient rise in BP due to increased intrathoracic pressure. Early phase II (phase II_{early}) is a fall in BP due to reduced cardiac preload (venous return) and stroke volume. The fall in BP is sensed by arterial baroreceptors in the carotid sinus and aortic arch, mediated centrally via glossopharyngeal and vagal afferents, and corrected by sympathetic activation (vasoconstriction and positive inotropic and chronotropic effects on the heart) and vagal withdrawal (cardioacceleration). The resulting rise in BP is described as late phase II (phase II_{late}). At the end of the Valsalva maneuver, the sudden fall in intrathoracic pressure results in a transient fall in BP (phase III), lasting 1 to 2 seconds. In phase IV, venous return normalizes while cardiac output is still increased and the arterial vascular bed is still constricted, resulting in a transient BP overshoot [3]. These BP changes are accompanied by changes in HR. During phase I, heart rate increases in response to the fall in BP mainly as a result of vagal withdrawal. That rise in HR continues during phase II_{late} as a result of sympathetic activation. During phase IV, HR decreases in response to the BP rise and overshoot (vagal activation). Phase II_{early} and phase IV therefore lend themselves to derive information about baroreflex sensitivity.

Our program has made significant headway in developing non-invasive methodology to quantify vagal and sympathetic components of the baroreflex [4, 5]. The vagal component of the baroreflex (BRS_{vagal}) can be quantified by relating the HR response (as R-R interval response) to a preceding change in BP. Traditionally, BRS_{vagal} has been measured by the modified Oxford method, where the R-R interval response to an induced fall in BP (by intravenous boluses of nitroprusside) and an induced rise in BP (by intravenous boluses of phenylephrine) is studied sequentially [6]. BRS_{vagal} is determined as the slope of the R-R interval -BP response and expressed as ms/mmHg. In the Autonomic Laboratory, we have focused on the R-R interval response to the fall in SBP during phase II_{early} of the Valsalva maneuver. We previously validated the method in patients with graded autonomic failure [4] and have generated normative values [5].

Only few studies have been devoted to the R-R interval response to the rise in BP following the Valsalva maneuver. The previously described methodologies relating R-R interval to BP increase during phase IV of the maneuver have only limited application in the Autonomic

Laboratory, since phase IV is typically absent in patients with NOH [7-9]. There is a need for an approach that relates R-R interval to BP increase that is reliably present not only in healthy subjects, but also in patients with autonomic failure. Therefore, we sought to determine BRS_{vagal} by relating R-R interval to the rise in BP that follows phase III of the maneuver.

The aims of this study were: (1) to evaluate if BRS_{vagal} can be determined from the rise in BP during phase III-IV of the Valsalva maneuver (BRS_{vagal_{inc}}); (2) to assess the association between BRS_{vagal_{inc}} and BRS_{vagal} derived from the preceding BP decrement (BRS_{vagal_{dec}}); and (3) to validate BRS_{vagal_{inc}} as an index of autonomic function.

METHODS

Study Participants

The study was approved by the Mayo Clinic Institutional Review Board. We included patients with different degrees of autonomic failure and age- and sex-matched healthy control subjects. Patients with autonomic failure were divided into two groups: (1) patients with severe autonomic failure (severe AF), defined as blood pressure recovery time (ABP_{RT}) following the Valsalva maneuver of greater than 10 seconds; and (2) patients with mild autonomic failure (mild AF), defined as ABP_{RT} of greater than 5 seconds but less than 10 seconds.

A total of 101 subjects (54 men, 57 women) were included in the study. The severe AF group included 49 patients (25 female; age 51.5 ± 15.3 years), the mild AF group included 25 patients (11 female; age 57.5 ± 15.7 years), and the control group included 29 subjects (15 female; age 51.5 ± 15.3 years). We excluded patients with conditions such as cardiac, pulmonary, hepatic, renal, hematologic, and neoplastic disorders and patient with neurocardiogenic syncope. Patients on medications known to cause OH or otherwise affect autonomic testing were asked to discontinue use of the drug for 5 half-lives, if such a procedure was not harmful to the well-being of the patient. For patients on levodopa/carbidopa, the drug was omitted on the day of the study and resumed after the test.

Study Protocol

HR was recorded using a standard 3-lead electrocardiogram (Ivy Biomedical Systems, Inc, Branford, Conn). Arterial BP was continuously measured at the finger using beat-to-beat photoplethysmographic recordings (Finapres BP monitor model 2300 and Finometer; Ohmeda, Englewood, Colo).

All subjects underwent standardized autonomic reflex testing to evaluate the severity and distribution of sudomotor, sympathetic, and cardiovascular function [10]. The Valsalva maneuver was performed with the patient supine. The patient was instructed to maintain a column at 40 mm Hg for 15 seconds via a tube with an air leak (to ensure an open glottis). After a practice run, the subject performed a series of maneuvers until two reproducible responses were obtained.

Variables

The baseline values of systolic, diastolic, and mean arterial BP were determined with the subject rested and supine for at least 20 minutes preceding the Valsalva maneuver, and derived as a 30 second average before the Valsalva maneuver. ABP_{RT} was defined as time in seconds from the valley of phase III until BP returned to baseline. The magnitude of BP changes was determined for phase II_{early}, phase II_{late}, and phase IV. Sympathetic barosensitivity (BRS_{symp}) was calculated as systolic BP decrement associated with phase III divided by ABP_{RT} [4]. R-R interval response to BP rise (BRS_{vagal_{inc}}) was defined as the regression slope of R-R interval over SBP from start of phase III to peak of phase IV (or SBP return to baseline). R-R interval response to BP fall (BRS_{vagal_{dec}}) was expressed as the regression slope of R-R interval over SBP during phase II_{early}.

Previous experience with the use of BRS_{vagal_{dec}} has led to the observation that subjects with excessively rapid BP changes during phase II_{early} can have spuriously low regression slopes, presumably due to a supramaximal stimulus and limitations in the speed of the vagally mediated HR response. Although not strictly assessing BRS, we have used an alternative parameter, HR slope that seems to provide helpful information in those situations. HR slope is derived as the regression slope of HR over time (in seconds) during phase II_{early} (HRslope_(inc)) and from phase III to the peak of phase IV (HRslope_(dec)). We have included this parameter in this study as well to explore its validity.

Statistical Analysis

Continuous variables are expressed as mean $\pm$ SD. We used one-way analysis of variance with post hoc Bonferroni analysis to examine group differences; paired t test was used to analyze normally distributed data. The relationship between SBP and R-R interval was assessed using regression analysis. Regression and correlation analysis, using Pearson's or Spearman's test was performed as appropriate. All statistical tests were two-tailed and $P < 0.05$ was considered significant for all comparisons. Receiver operator characteristic curve analysis was used to assess predictive value and cut-off values for BRS_{vagal_{inc}} and BRS_{vagal_{dec}}, as well as HRslope_(inc) and HRslope_(dec).

Receiver Operating Characteristic Curve

A receiver operating characteristic curve was used to calculate the relationship between sensitivity and specificity for the Control group vs mild and severe AF groups; evaluating the diagnostic performance of BRS_{vagal_{dec}} and BRS_{vagal_{inc}}. The curve cutoff value is determined by tying the sensitivity to a value of greater than 90%, with a few exceptions where the sum of sensitivity and specificity is maximal even though the sensitivity is below 90%.

RESULTS

Baseline hemodynamic indices

Baseline BP and HR indices are summarized in Table 1. There were differences in SBP, MBP, and HR between groups ($p = 0.001$ for SBP, $p = 0.004$ for MBP, and $p < 0.001$ for HR). Post-hoc comparisons revealed significant differences in SBP and MBP between

severe AF and controls and severe AF and mild AF. Baseline HR was different between severe AF and controls and mild AF and controls. Baseline DBP did not differ among the groups.

BRS indices and parameters of Valsalva maneuver

BRS_{vag_{inc}} could be calculated in all subjects across all patient groups (Table 2, Figure 1). Group values for BRS_{vag_{inc}}, BRS_{vag_{deg}}, and BRS_{symp} were all highest in controls and were lowest in severe AF (Figure 1, Table 2). There were significant overall differences between groups (p values all <0.001). BRS_{vag_{inc}} was significantly higher than BRS_{vagal_{dec}} in all groups (Figure 1). Post hoc analysis showed that the difference in BRS_{vag_{inc}} and BRS_{vagal_{dec}} was significant between severe AF and controls and mild AF and controls (Figure 1, Table 2). BRS_{symp} was significant between all groups. Similarly, HR_{slope(inc)} and HR_{slope(dec)} were highest (absolute values) in controls and lowest in severe AF, with similar overall and post-hoc group differences as the BRS parameters (Table 2).

The amplitude of phase II_{late} and phase IV was highest in controls and markedly blunted in both patient groups. The amplitude of phase II_{early} was highest in severe AF. There was again an overall significant difference between groups ($p <0.001$). Group by group comparisons are summarized in Table 2.

Correlation between BRS and other parameters derived from the Valsalva maneuver

We correlated the parameters of BRS to the magnitude of BP changes during Valsalva maneuver, ABPRT, and HR_{slope}. The correlations were all significant ($p <0.001$). The coefficients are listed in Table 3. Notably, BRS_{vagal_{inc}} significantly correlated with previously utilized phases of the Valsalva maneuver and symp athletic barosensitivity, with highest correlations with BRS_{vagal_{dec}}. The relationship between BRS_{vagal_{inc}} and BRS_{vagal_{dec}} for all patient groups is illustrated in Figure 2. HR_{slope(inc)} was significantly lower than HR_{slope(dec)} in controls but not in the patient groups (Table 2).

Receiver Operator Characteristic Curve analysis

Receiver operator characteristic curve analysis was used to determine optimal cut-off values from normal for severe AF and mild AF groups for BRS_{vag_{inc}} and BRS_{vagal_{dec}}. Areas under the curve (AUC) for BRS_{vagal_{inc}} and BRS_{vagal_{dec}} are shown in Figure 3.

AUC for BRS_{vagal_{inc}} was 0.86 and AUC for BRS_{vagal_{dec}} was 0.94 in the model of comparing severe AF with controls (Figure 3-A). The cut off value of BRS_{vagal_{inc}} was 5.99 for differentiating severe AF from controls with a sensitivity of 0.94 and specificity of 0.62. The cut off value of BRS_{vagal_{dec}} was 2.34 for differentiating severe AF from controls with a sensitivity of 0.82 and specificity of 0.93.

AUC for BRS_{vagal_{inc}} was 0.78 and AUC for BRS_{vagal_{inc}} was 0.88 in the model of comparing mild AF with controls (Figure 3-B). The cut off value of BRS_{vagal_{inc}} was 5.66 for differentiating mild AF from controls; sensitivity and specificity were 0.88 and 0.62, respectively. The cut off value of BRS_{vagal_{inc}} was 3.03 for differentiating mild AF from controls; sensitivity and specificity were 0.88 and 0.83, respectively.

Receiver operator characteristic curves were also created for $\text{HRslope}_{(\text{inc})}$ and $\text{HRslope}_{(\text{dec})}$. A cut-off value for $\text{HRslope}_{(\text{inc})}$ of 1.58 separated controls from severe AF with 90% sensitivity and 83% specificity, while a cut-off value of 2.44 separated controls from mild AF with 88% sensitivity and 69% specificity. A cut-off value for $\text{HRslope}_{(\text{dec})}$ of -1.66 separated controls from severe AF with 84% sensitivity and 97% specificity, while a cut-off value of -2.30 separated controls from mild AF with 88% sensitivity and 90% specificity.

DISCUSSION

The pertinent findings of this study can be summarized as follows:

1. $\text{BRS}_{\text{vagal}}$ can be readily determined from the R-R interval response to the BP increase during phase III-IV of the Valsalva maneuver in normal controls as well as patients with different degrees of autonomic failure.
2. $\text{BRS}_{\text{vagal}_{\text{inc}}}$ shows a graded decrease with increasing degrees of autonomic failure.
3. $\text{BRS}_{\text{vagal}_{\text{inc}}}$ shows a high association with other indices of autonomic failure, and particularly with other indices of baroreflex function.
4. HRslope shows a similar pattern of differences across patient groups as $\text{BRS}_{\text{vagal}}$, and has potential application as surrogate marker of baroreflex sensitivity in subjects with spuriously low $\text{BRS}_{\text{vagal}}$ due to excessively rapid BP changes during the Valsalva maneuver.
5. Cut-off values between 5.6 and 6.0 ms/mmHg for $\text{BRS}_{\text{vagal}_{\text{inc}}}$ and between 2.3 and 3.0 ms/mmHg for $\text{BRS}_{\text{vagal}_{\text{inc}}}$ reasonably differentiate normal from abnormal vagal baroreflex function in middle-aged adults.

Assessing vagal baroreflex function provides important information about autonomic nervous system function and its impairment. The modified Oxford technique is considered the gold standard in assessing $\text{BRS}_{\text{vagal}}$, but requires pharmacologic manipulations of BP and is therefore not suited for routine application in the clinical autonomic laboratory [6]. The Valsalva maneuver is part of a routine battery of tests to non-invasively assess autonomic nervous system function, and has been shown to provide quantifiable information about vagal baroreflex function by assessing the vagal response to alterations in BP [9]. While the HR or R-R interval response to the BP decrease during phase II_{early} is widely used for this purpose, previously reported indices derived from the HR or R-R interval response to the BP increase during phase IV have not found broader application, owing to the fact that patients with autonomic failure lack a BP overshoot during phase IV [9, 11]. In contrast, phase III is mostly mechanical and is universally present. Here, we propose a parameter for vagal baroreflex function derived from the BP increase during phase III and IV, which can be derived regardless of the development of a phase IV overshoot. We were able to demonstrate that this parameter could indeed be calculated from routine BP and HR recordings of all subjects enrolled in this study.

The next step in establishing this new parameter was to prove its validity by assessing its values across different degrees of autonomic failure and by assessing its association with other indices of baroreflex function. We could demonstrate that $\text{BRS}_{\text{vagal}_{\text{inc}}}$ shows a graded

and highly significant decrease with increasing degrees of autonomic failure. We could also show that $BRS_{vagal_{inc}}$ has strong associations with other indices of autonomic failure, and particularly with other indices of baroreflex function. The association with another index of *vagal* baroreflex function ($BRS_{vagal_{inc}}$) was stronger than associations with indices of *sympathetic* baroreflex function (BRS_{symp} , ABP_{RT}). That is expected since the vagal baroreflex arc shares only the afferent but not the efferent pathways with the sympathetic baroreflex arc, and is consistent with clinical and laboratory observations that each component may be selectively or differentially involved in certain autonomic disorders. This observation is also consistent with previous reports that there is no correlation between sympathetic activity and vagal baroreflex gain [5, 6].

We found the values for $BRS_{vagal_{inc}}$ higher than those for $BRS_{vagal_{dec}}$ across all patient groups. Rudas et al. using the modified Oxford technique also report vagal baroreflex slopes being higher when arterial pressures are rising than when they are falling, and this hysteresis was seen over pressure ranges both below and above baseline levels [6]. The values derived for vagal baroreflex gain in this and other studies using the Oxford technique are, however, generally higher than those we found in this as well as previous studies on BRS_v derived from the Valsalva maneuver [4-6]. The reason for this difference is not known, but we speculate that it relates to temporal differences in BP changes. BP changes during the Valsalva maneuver occur quite rapidly, with BP changes of 50 mmHg or more over a few seconds not infrequently seen, while BP changes induced by pharmacological interventions occur much slower. In fact, we have seen spuriously low BRS_{vagal} values in healthy controls with particularly rapid BP changes ("exaggerated early phase II").

This presumably relates to a supramaximal stimulus and limitations in the speed of the vagally mediated HR response.

We have therefore used an alternative parameter, HR slope, that seems to provide helpful information in those situations. This index measures the HR change during phase II_{early} and during phase III-IV as a function of time rather than as a function of BP change. Although not strictly assessing BRS, we have used this index as surrogate marker of baroreflex function in those circumstances and have therefore included evaluations of this parameter in this study. $HRslope_{(inc)}$ and $HRslope_{(dec)}$ showed a very similar pattern of differences across patient groups as $BRS_{vagal_{inc}}$ and $BRS_{vagal_{dec}}$. Our data suggest that one can reasonably postulate normal vagal baroreflex sensitivity if the slope of HR increment is greater than 2.44 and/or the slope of HR decrement is lower than -2.30 in cases where BRS appears spuriously low due to excessively rapid changes in BP.

While previous studies have used the degree of orthostatic hypotension to evaluate the severity of autonomic failure, in the present study we used the length of ABP_{RT} to distinguish the severity of autonomic failure [4, 12]. We believe that the use of this parameter is superior to using the degree of orthostatic hypotension. Orthostatic hypotension is seen only with severe degrees of sympathetic failure [10], while ABP_{RT} shows a graded increase with increasing degrees of autonomic failure [12]. The only direct method to measure the intactness of baroreflex-mediated sympathetic activation is through microneurographic recordings of muscle sympathetic nerve activity [13], a procedure that is

too invasive, time-consuming, and technically too demanding for routine clinical usage. ABP_{RT} offers the opportunity to evaluate intermediate levels of severity of sympathetic failure noninvasively.

The main limitations of this study are that the study is retrospective and depends on the accuracy of Finapres recorded beat-to-beat BP changes. Since BRS values calculated using this method are substantially different from those derived from the modified Oxford method, BRS values should not be directly compared across the different techniques. The provided cut-off values from normal are based on relatively small numbers of subjects. A study formally establishing normative data for this new index of baroreflex function in a large group of subjects is currently in progress.

CONCLUSION

Vagal baroreflex sensitivity can be readily determined from the R-R interval response to the BP increase during phase III-IV of the Valsalva maneuver, complementing the assessment of baroreflex pathways in the clinical autonomic laboratory.

CLINICAL PERSPECTIVES

In the clinical autonomic laboratory, noninvasive methodology is available to measure beat-to-beat BP and heart rate. The autonomic clinician can recognize patterns of autonomic failure. Although this qualitative approach is important, quantifying baroreflex function adds a new dimension of accuracy and sophistication. We add the component of BRS_{vagal_{inc}}, which together with BRS_{vagal_{inc}} and BRS_{symp}, enable a complete yet simple analysis of baroreflex function. This approach has value in the diagnosis of autonomic failure and monitoring the progression of disease and the response to treatment.

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Figure 1.

Vagal baroreflex sensitivity for BRSvagal_{dec} and BRSvagal_{inc} for controls, patients with mild and severe AF. Error bar represents a 95% confidence interval.

Figure 2.

Correlation between $\text{BRSvagal}_{\text{dec}}$ and $\text{BRSvagal}_{\text{inc}}$ in (A) all study subjects, (B) severe AF, (C) mild AF, and (D) control.

Figure 3. Receiver operator curves showing sensitivity and 1-specificity for BRSvagal_{inc} and BRSvagal_{dec} in the model of comparing severe AF to control (A); mild AF to control (B). * represent the cut off points for each value.

Table 1

Baseline blood pressure and heart rate indices for control and patients with graded autonomic failure

		severe AF (n = 49)	mild AF (n = 25)	Control (n = 29)
SBP	(mmHg)	152.0 ± 26.4 ^{†‡}	135.5 ± 22.9 *	132.7 ± 14.6 *
MBP	(mmHg)	101.6 ± 18.4 ^{†‡}	90.7 ± 13.9 *	91.8 ± 9.9 *
DBP	(mmHg)	76.7 ± 17.4	68.7 ± 12.9	71.8 ± 9.0
HR		78.5 ± 15.5 [‡]	72.7 ± 10.9 *	62.5 ± 8.2 ^{*†}

Values are expressed as mean ± SD.

severe AF, Severe autonomic failure; mild AF, Mild autonomic failure; SBP, systolic blood pressure; MBP, mean blood pressure; DBP, diastolic blood pressure; HR, heart rate

*
vs severe AF[†]
vs mild AF[‡]
vs Control. P < 0.05.

Table 2

The parameters of the Valsalva maneuver and baroreflex sensitivity in patients with autonomic failure and controls

		severe AF	mild AF	Control
BRS _{vagal_{inc}}	(ms/mmHg)	2.46 ± 2.30 [‡]	3.51 ± 1.98 [‡]	6.50 ± 3.10 ^{*‡}
BRS _{vagal_{dec}}	(ms/mmHg)	1.27 ± 1.31 [‡]	2.24 ± 1.19 [‡]	4.99 ± 2.11 ^{*‡}
BRS _{symp}	(mmHg/s)	3.28 ± 1.81 ^{†‡}	10.07 ± 3.29 ^{*‡}	32.21 ± 14.31 ^{*‡}
Phase II _{early}	(mmHg)	31.25 ± 16.6 ^{†‡}	22.79 ± 11.17 ^{*‡}	6.94 ± 9.05 ^{*‡}
Phase II _{late}	(mmHg)	1.53 ± 2.51 [‡]	1.40 ± 2.12 [‡]	12.38 ± 6.83 ^{*‡}
Phase IV	(mmHg)	4.48 ± 5.11 ^{†‡}	9.77 ± 6.38 ^{*‡}	22.51 ± 11.98 ^{*‡}
ABP _{RT}	(S)	28.78 ± 14.30 ^{†‡}	7.08 ± 1.40 ^{*‡}	1.72 ± 0.82 ^{*‡}
HRslope _(inc)	(beat/s)	0.75 ± 0.84 ^{†‡}	1.15 ± 0.99 ^{*‡}	3.02 ± 1.53 ^{*‡}
HRslope _(dec)	(beat/s)	-0.86 ± 1.03 [‡]	-1.92 ± 2.27 [‡]	-7.06 ± 3.88 ^{*‡}

BRS, baroreflex sensitivity; ABP_{RT}, blood pressure recovery time; HRslope, heart rate slope

* vs severe AF

† vs mild AF

‡ vs Control. P < 0.05.

Table 3

Correlations between BRS with components of Valsalva maneuver, PRT and HRS

	BRSvagal _{inc}	BRSvagal _{dec}	BRSsymp	Phase II _{early}	Phase II _{late}	Phase IV	ABP _{RT}	HRSlope _(inc)	HRSlope _(dec)
BRSvagal _{inc}	—	0.721	0.413	-0.460	0.422	0.282	-0.466	0.531	-0.636
BRSvagal _{dec}		—	0.571	-0.515	0.551	0.443	-0.571	0.722	-0.661
BRSsymp			—	-0.418	0.816	0.792	-0.612	0.646	-0.705
Phase II _{early}				—	-0.485	-0.401	0.550	-0.611	0.418
Phase II _{late}					—	0.605	-0.458	0.489	-0.586
Phase IV						—	-0.550	0.642	-0.702
ABP _{RT}							—	-0.522	0.517
HRSlope _(inc)								—	-0.817
HRSlope _(dec)									—

BRS, baroreflex sensitivity; ABP_{RT}, blood pressure recovery time; HRS, heart rate slope