Systemic vascular effects of acute electrical baroreflex stimulation

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Burgoyne S, Georgakopoulos D, Belenkie I, Tyberg JV. Systemic vascular effects of acute electrical baroreflex stimulation. Am J Physiol Heart Circ Physiol 307: H236–H241, 2014. First published May 9, 2014; doi:10.1152/ajpheart.00422.2013.—We intended to determine if acute baroreflex activation therapy (BAT) increases venous capacitance and aortic conductance. BAT is effective in resistant hypertension, but its effect on the systemic vasculature is poorly understood. Left ventricular (LV) and aortic pressures and subdiaphragmatic aortic and caval flows (ultrasonic) were measured in six anesthetized dogs. Changes in abdominal blood volume (Vabdominal) were estimated as the integrated difference in abdominal aortic inflow and caval outflow. An electrode was implanted on the right carotid sinus. Data were measured during control and BAT. Next, sodium nitroprusside (SNP) was infused and BAT was subsequently added. Finally, angiotensin II (ANG II) was infused, and three increased BAT currents were added. We found that BAT decreased mean aortic pressure (Pao) by 22.5 ± 1.3 mmHg (P < 0.001) and increased aortic conductance by 16.2 ± 4.9% (P < 0.001) and Vabdominal at a rate of 2.2 ± 0.6 ml·kg⁻¹·min⁻¹ (P < 0.001). SNP decreased Pao by 17.4 ± 0.7 mmHg (P < 0.001) and increased Vabdominal at a rate of 2.2 ± 0.7 ml·kg⁻¹·min⁻¹ (P < 0.05). During the SNP infusion, BAT decreased Pao further, by 26.0 ± 2.1 mmHg (P < 0.001). ANG II increased Pao by 40.4 ± 3.5 mmHg (P = 0.001). When an increased BAT current was added, Pao decreased to baseline (P < 0.01) while aortic conductance increased from 62.3 ± 5.2% to 80.2 ± 3.3% (P < 0.05) of control. Vabdominal increased at a rate of 1.8 ± 0.9 ml·kg⁻¹·min⁻¹ (P < 0.01), reversing the ANG II effects. In conclusion, BAT increases arterial conductance, decreases Pao, and increases venous capacitance even in the presence of powerful vasoactive drugs. Increasing venous capacitance may be an important effect of BAT in hypertension.

baroreceptors; venous capacitance; aortic conductance

Electrical baroreceptor activation therapy (BAT) can be achieved with an implantable medical device (CVRx Inc.) and has been used to treat resistant hypertension (27). There is also potential for this approach to be useful in heart failure (11). While the effects of BAT on cardiac function (i.e., heart rate, contractility, and cardiac output) have been established (11), the effects on the peripheral circulation (i.e., arterial conductance and venous capacitance) have not been defined.

Control of venous capacitance is important in the maintenance of cardiovascular homeostasis and cardiac output (35). Modulation of venous capacitance by sympathetic outflow has been demonstrated with studies during electrical stimulation, including splanchnic and hepatic nerves (5, 7), changes in carotid artery pressure (31), and pharmacological manipulation of sympathetic activity (23). The control of vascular capacitance by the carotid baroreflex has been well-investigated and demonstrated (30). While the effects of BAT on left ventricular (LV) preload (11) have been reported, the potential contribution of changes in venous capacitance to the mechanism by which BAT lowers blood pressure has not been examined.

Using a modified Brooksby-Donald technique (37), we designed a study to estimate acute changes in abdominal blood volume and arterial conductance during BAT, alone and when applied simultaneously with vasoactive agents. To compare the arterial and venous vasodilating effects of BAT to those of a well-known vasodilator, we used the potent arterial and venous vasodilator, sodium nitroprusside (SNP), in doses that substantially decreased aortic pressure. The effects of BAT were also assessed in the presence of SNP to determine if the effects would be additive. Infusion of the arterial and venous (32) vasconstrictor, angiotensin II (ANG II), allowed BAT to be tested in the presence of substantial vasoconstriction. We hypothesized that the application of BAT would increase abdominal blood volume (as assessed by the Brooksby-Donald technique), that the magnitude of this change might be smaller during the infusion of SNP, and that the effect of BAT might be greater when blood had been mobilized from the splanchnic to the central circulation during the ANG II infusion (34).

Methods

Animal preparation. Using a protocol approved by the institutional animal care committee, experiments were performed in six healthy mongrel dogs [21.7 ± 4.2 (SD) kg] of either sex. Anesthesia was initiated with thiopental (25 mg/kg) and maintained with fentanyl citrate (0.2 mg·kg⁻¹·h⁻¹, adjusted as necessary to maintain deep anesthesia) and midazolam (0.05 mg·kg⁻¹·h⁻¹). The animals were intubated and ventilated with a constant-volume respirator (Harvard Apparatus, Holliston, MA; tidal volume 15 ml/kg) and a closed rebreathing system to maintain normal blood gases and pH. Body temperature was maintained between 36.5°C and 37.5°C with a warming blanket. An ECG was recorded throughout.

With the dogs in the supine position, a catheter was advanced to the right atrium through the left jugular vein for fluid and drug infusions. A midline sternotomy was performed and the pericardium was opened with a base-to-apex incision. Sonomicrometry crystals (Sonometrics, London, ON), were implanted in the LV endocardium and the midwall of the septum to provide septum-to-LV free wall and anteroposterior dimensions. A 7-Fr, pig-tail catheter-tipped manometer (model FTM-7011B-048A, Scisense, London, ON) was inserted into the LV via the apex. The pericardium was loosely reapproximated with sutures to avoid excessive constraint (28). A 3.5-Fr Mikro-tip catheter (model SPR-524, Millar Instruments, Houston, TX) was advanced to the ascending aorta via the right brachial artery. A 7-Fr catheter-tipped manometer (model FTM-7011B-0048C, Scisense) with a fluid-filled reference lumen was introduced via the right femoral artery and advanced to the abdominal aorta. All pressures were referenced to the...
midlevel of the right atrium. Ultrasonic flow probes (Transonic Systems, Ithaca, NY) were implanted on the ascending aorta, the aorta above the diaphragm, and the inferior vena cava above the diaphragm. The right carotid artery was dissected and the electrode (CVRs, Minneapolis, MN) was implanted on the artery with a wrap-around band at the level of the carotid sinus.

Data recorded include aortic pressure (PAn), LV end-diastolic pressure (PLVED), aortic flow (Qao-asc), diaphragmatic aortic flow (Qao-dia), inferior vena caval flow (Qivc), and heart rate (HR). Data were collected and the device was activated at a rate of 2.2 mA and 4.4 mA greater than current 1. After a 15-min stabilization interval was then allowed to elapse before the protocol began. Data were recorded while the ventilator was turned off at end-expiration for a period of 20 s. Data were collected during each device activation and drug infusion. The device was activated at current 1 for 5 min, after which blood pressure was allowed to return to baseline. SNP was then infused (14 μg·kg⁻¹·min⁻¹); after hemodynamic stability was achieved and data had been collected, the device was activated again at current 1.

Data analysis. Conductance, which is the amount of flow a vascular bed will accept per unit of driving pressure and is the reciprocal of resistance, was calculated as mean Qao-asc divided by mean PAn (venous pressure was not measured). Stroke volume (SV) was calculated as the integral of Qao-asc during systole. Cardiac output (CO) is the product of SV and HR. The product of septum-to-LV free wall and LV anterior-posterior dimensions, end-diastolic LV area (AreaLVED), was used as an index of LV end-diastolic volume (3).

Changes in subdiaphragmatic blood volume were calculated using a modified Brooksby-Donald technique (37). Under stable baseline conditions, Qao-dia was arbitrarily adjusted to equal Qivc; thus, assuming that inflow equaled outflow, a baseline interval of constant blood volume was defined. After an intervention, the difference between Qao-dia and Qivc was integrated over the first minute and the slope of the volume vs. time curve was used to estimate the rate of change of volume (ml/min) (see Fig. 1).

Statistical analysis. Absolute values for hemodynamic measures were used for comparison except for conductance (baseline set at 100%) and capacitance [volume change during first minute of the intervention (ml·kg⁻¹·min⁻¹)]. Results are presented as means ± SE. The Student’s paired t-test was used to determine statistical significance for BAT vs. baseline. One-way repeated-measures ANOVA was used to determine statistical significance for comparisons among SNP, SNP with BAT, and baseline, as well as among ANG II, ANG II with multiple BAT currents, and baseline. Post hoc multiple comparisons were determined by Fisher’s least significant difference (LSD) test. A value of P < 0.05 was considered significant.

RESULTS

The current required to lower mean PAn by ~20 mmHg (current 1) was 6.8 ± 3.4 (SD) mA. Currents 2 and 3 were, respectively, 2.6 ± 1 mA and 4.4 ± 1.5 mA greater than current 1. Baseline inferior vena caval flow was 0.91 ± 0.22 (SD) times the aortic flow at the diaphragm.

Effects of BAT. The effects of BAT are shown in Table 1 and Fig. 2. BAT decreased mean PAn by 22.5 ± 1.5 mmHg (P < 0.001). This was associated with a 16.0 ± 4.9% increase in arterial conductance (P < 0.05) and a 14.3 ± 2.6% decrease in HR (P < 0.01). Abdominal blood volume increased at a rate of 2.2 ± 0.6 ml·kg⁻¹·min⁻¹ (P < 0.01).

Effects of SNP and BAT (n = 5). As shown in the middle column of Fig. 2 and listed in Table 1, SNP decreased mean PAn by 17.4 ± 0.8 mmHg (P < 0.001). Arterial conductance increased by 76.0 ± 22.0% (P < 0.05) and HR increased by 44.9 ± 10.4% (P < 0.05). Abdominal blood volume increased at a rate of 2.2 ± 0.7 ml·kg⁻¹·min⁻¹ (P < 0.05). During SNP administration, BAT decreased mean PAn by 26.0 ± 2.1 mmHg (P < 0.001), which was similar to the change due to BAT during the control state (22.5 ± 1.5 mmHg). BAT increased arterial conductance further by 116.0 ± 16.5% of baseline (P < 0.05). The rate of change of abdominal blood volume tended to increase further relative to baseline, to 5.1 ± 2.2 ml·kg⁻¹·min⁻¹ (P = 0.06). The decrease in HR was not statistically significant (~17.2 ± 3.6%, P = 0.12).

Effects of ANG II with BAT. The effects of ANG II are listed in Table 2 and shown in the right-hand column of Fig. 2. ANG

| Table 1. Results of BAT during the control state, SNP, and BAT during SNP administration |
|---------------------------------------------|-------------|-------------|-------------|-------------|
| SV, ml | 15.7 ± 2.0 | 16.4 ± 2.0 | 14.8 ± 2.3 | 15.5 ± 3.3 | 14.6 ± 1.9 |
| CO, ml/min | 1,106 ± 154 | 984 ± 151 | 1,069 ± 197 | 1,652 ± 432 | 1,309 ± 295 |
| PLVED, mmHg | 9.1 ± 0.4 | 6.6 ± 0.7* | 8.8 ± 0.6 | 5.1 ± 0.7* | 4.4 ± 0.8* |
| AREALVED, mm² | 1,275 ± 102 | 1,205 ± 100* | 1,282 ± 126 | 1,114 ± 119* | 1,074 ± 115* |

Values are means ± SE. BAT, baroreflex activation therapy; SNP, sodium nitroprusside; SV, stroke volume; CO, cardiac output; PLVED, left ventricular end-diastolic pressure; AREALVED, left ventricular end-diastolic area. *P < 0.05, intervention vs. baseline.

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II increased mean $P_{Ao}$ by $40.4 \pm 3.5$ mmHg ($P = 0.001$) and decreased conductance by $37.7 \pm 5.2\%$ ($P < 0.01$). Abdominal blood volume decreased at a rate of $1.4 \pm 0.5$ ml·kg$^{-1}$·min$^{-1}$ ($P < 0.05$). There was a trend for HR to increase ($18.2 \pm 2.5\%$, $P = 0.06$).

During ANG II infusion, BAT (current 1) reduced mean $P_{Ao}$ by $22.2 \pm 4.9$ mmHg ($P < 0.01$), but did not change arterial conductance. The BAT-induced decrease in mean $P_{Ao}$ was equal to that during the control state (i.e., 22 mmHg). HR decreased by $12.1 \pm 1.7\%$ ($P < 0.05$). BAT at current 3 during ANG II infusion reversed the $P_{Ao}$ effects of ANG II, decreasing mean $P_{Ao}$ by $7.7$ mmHg ($P < 0.01$), while HR did not change significantly with BAT at current 2 or 3. Currents of BAT increased conductance from $62.3 \pm 5.2\%$ to $80.2 \pm 3.3\%$ of baseline ($P < 0.01$). Currents of BAT reversed the ANG II-induced decrease in abdominal blood volume; abdominal blood volume then increased at rates of $1.7 \pm 0.9$ ml·kg$^{-1}$·min$^{-1}$ ($P < 0.05$) and $1.8 \pm 0.9$ ml·kg$^{-1}$·min$^{-1}$ ($P < 0.05$), respectively.

DISCUSSION

As has been demonstrated previously (27), BAT caused a substantial reduction in mean arterial blood pressure. In the present study, the major new findings are that BAT caused a substantial increase in venous capacitance and arterial conductance. These effects occurred when BAT was applied alone and also during administration of large doses of ANG II; they also tended to occur during SNP administration ($P = 0.06$). The increase in venous capacitance during BAT was comparable to that provided by a relatively high dose of SNP [14 $\mu$g·kg$^{-1}$·min$^{-1}$]. Increasing BAT currents were able to reverse the effects of ANG II on venous capacitance, a potentially important effect of this technology with respect to its clinical applications (10). With increasing currents of BAT during ANG II administration, mean aortic pressure returned to baseline values and arterial conductance increased, although not to baseline values.

Capacitance and conductance. Vasoactive agents lengthen or shorten the smooth muscle arranged circumferentially in the walls of arterial and venous vessels. For instance, vasodilators (including BAT) lengthen (relax) arterial smooth muscle to increase arterial caliber and conductance, and they relax venous smooth muscle to increase venous caliber and capacitance. With respect to conductance, arterial effects dominate as venous resistance is very small compared with that of small arteries and arterioles. With respect to capacitance, venous

Table 2. Results of BAT during ANG II administration: currents 1, 2, and 3

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>ANG II</th>
<th>ANG II + BAT (Current 1)</th>
<th>ANG II + BAT (Current 2)</th>
<th>ANG II + BAT (Current 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SV, ml</td>
<td>16.9 ± 2.7</td>
<td>12.4 ± 1.8*</td>
<td>12.5 ± 1.9*</td>
<td>12.3 ± 1.4*</td>
<td>11.2 ± 1.1*</td>
</tr>
<tr>
<td>CO, ml/min</td>
<td>1.171 ± 238</td>
<td>978 ± 143</td>
<td>885 ± 150†</td>
<td>880 ± 137*</td>
<td>762 ± 70†</td>
</tr>
<tr>
<td>$P_{LVED}$, mmHg</td>
<td>8.5 ± 0.6</td>
<td>12.0 ± 0.6*</td>
<td>10.5 ± 0.4</td>
<td>9.8 ± 0.5</td>
<td>10.0 ± 0.4‡</td>
</tr>
<tr>
<td>$A_{LVED}$, mm²</td>
<td>1.217 ± 112</td>
<td>1.360 ± 141*</td>
<td>1.275 ± 144‡</td>
<td>1.248 ± 157</td>
<td>1.286 ± 191†</td>
</tr>
</tbody>
</table>

Values are means ± SE. *$P < 0.05$, interventions vs. baseline. †$P < 0.05$, BAT vs. ANG II. ‡$P < 0.05$, currents 2 and 3 vs. current 1. §$P < 0.05$, current 3 vs. current 2.
effects dominate as venous capacitance is much greater than arterial capacitance. Venodilators can increase arterial capacitance relatively as much as they can increase venous capacitance (36). To compare venous and arterial effects quantitatively we developed plots of (venous) capacitance vs. (arterial) conductance (8, 14, 29, 35).

While BAT (current 1) caused a comparatively large increase in venous capacitance under several conditions, its effect on arterial conductance was less than that of SNP, which is not surprising given the very potent arterial dilating effects of that drug. This becomes apparent when the rate of change of capacitance is plotted against the percent change in conductance for BAT and SNP (see Fig. 3). Under the conditions of our study (i.e., anesthetized, ventilated animals), while capacitance changes resulting from our chosen dose of SNP and current of BAT were similar, SNP had a much greater effect on arterial conductance.

Although the increase in conductance with BAT is somewhat less than that of the chosen SNP dose, the potential importance of BAT’s conductance effect was observed when BAT was applied during SNP, when it still caused a large BP decrease, largely by increasing conductance.

The comparative effects of ANG II on capacitance and conductance are also interesting (see Fig. 3). ANG II decreased both conductance and capacitance, yet only the capacitance-decreasing effects (mobilizing blood to the central circulation) were fully reversed with increased BAT current. Although mean arterial pressure returned to pre-ANG II levels with the highest current of BAT (current 3), arterial conductance was not fully restored, only returning to 80% of baseline values.

BAT with vasoactive agents. BAT decreased blood pressure equally when applied either alone or during SNP infusion. It was also equally effective when applied during ANG II infusion. While our observations demonstrate the potent effects of BAT, the use of anesthesia precludes extrapolation of our findings to intact, awake subjects. Given the vasodilator effects of anesthesia in our experiments, it is likely that the effects would be at least as great in intact, awake subjects.

The ability of SNP to increase abdominal blood volume has been previously demonstrated (32, 37) so we might have expected that the BAT-induced decrease in blood pressure would be less when applied during infusion of SNP. However, while the chosen rate of SNP infusion was sufficient to lower mean Pao 17.4 ± 0.7 mmHg, BAT caused a further decrease of 26.0 ± 2.1 mmHg. This decrease was comparable to the BAT-induced decrease when applied alone (22.5 ± 1.5 mmHg). Given the different mechanisms by which BAT [through alteration of sympathetic and parasympathetic tone (11)] and SNP [through nitric oxide donation (15)] dilate vessels, we found that despite substantial vasodilatation by SNP, BAT dilated arterial and venous vessels further. With ANG II, the vasodilator effect of BAT on veins was also more prominent than its effect on arteries. However, we must acknowledge that BAT might not have produced any additional incremental effects in the presence of even larger doses of SNP and/or ANG II.

The ability of BAT to decrease blood pressure in the presence of ANG II is consistent with a previous report by Lohmeier et al. (18). In an investigation of BAT with chronic ANG II-induced hypertension, they showed that BAT decreased blood pressure by an amount equal to that under control conditions. Similarly, in our study, the effect of BAT (current 1) was not attenuated during the ANG II infusion. However, the key finding of Lohmeier et al. was that with no increase in BAT current and with continued infusion of ANG II, the effectiveness of BAT decreased by 80% after 1 wk. In our acute study, the ANG II-induced pressure increase was completely reversed in a current-dependent manner with BAT.

**Hemodynamic effects of BAT.** BAT profoundly affects three of the four determinants of CO (17): LV afterload, preload, and heart rate. The fourth, contractility, has been shown to be unaffected (11). When applied alone, BAT increases both arterial conductance and venous capacitance, thus tending to decrease both LV afterload and preload. Decreasing afterload tends to increase CO, and decreasing preload tends to decrease CO. In our anesthetized animals, the effect of the increase in conductance had a greater effect than any change in CO and mean arterial pressure always decreased. Normally, a decrease in arterial pressure produces an increase in heart rate (via the baroreceptor mechanism) but because of its direct effect on vagal outflow, BAT never increased heart rate.

While applying BAT seemed to decrease CO to a variable degree, the decrease was statistically significant only when BAT was applied during ANG II infusion. That ANG II + BAT should decrease CO is not surprising because BAT fully reversed the ANG II-induced venuconstriction (a preload-augmenting effect) but did not fully reverse the ANG II-induced arterial constriction (an afterload-aggravating effect). During SNP administration (decreased peripheral vascular resistance), it is not surprising that CO might increase or not change when BAT was added due to its effect of both decreasing afterload (increased conductance) and reducing LV preload.

**Mechanisms of BAT.** Studies by Lohmeier et al. (19) using BAT in awake, chronically instrumented dogs showed that the response was preserved despite complete adrenergic blockade of α1, β1, and β2 receptors, implicating a role for postsynaptic α2 receptors. Long-term follow-up of patients receiving BAT has shown sustained reductions in blood pressure despite their failure to respond to intensive pharmacological therapy with beta blockers, alpha blockers, and central sympatholytics (2).
Thus, while the baroreflex response is mediated through “sympathetic withdrawal,” any mechanistic insights would likely require complex studies such as those being performed by Fink and Osborn (16), where splanchnic nerve activity is recorded with arterial and venous sampling across the splanchnic bed. This would also allow for controlled assessment of different stimulation parameters (e.g., frequency coding vs. amplitude coding) on neurotransmitter release as these may involve different cellular mechanisms despite a common hemodynamic effect.

Clinical implications. Decreased vascular capacitance is a characteristic of both experimental (24, 38) and clinical (9) hypertension, where peripheral venous blood volume is reduced and blood is mobilized into the central circulation. This suggests that the ability of BAT to increase venous capacitance (i.e., to promote peripheral pooling) may prove to contribute to the success of the therapy in hypertensive subjects (4, 27). The elevated level of circulating ANG II in hypertensive patients is a common therapeutic target via blockade of the renin-angiotensin system (20). The ability of the device to lower blood pressure in the presence of ANG II is a promising result and consistent with the observations in chronic experiments (18) and the long-term demonstrated success of the device in hypertensive patients (27).

BAT is also seen as a potential therapy in heart failure (11). Neurohumoral stimulation in severe acute decompensated heart failure is the body’s attempt to improve cardiac output (10). However, the associated decrease in venous capacitance, which would be expected to increase LV preload, is of limited value because of pericardial constraint to filling and it may actually reduce LV preload by direct ventricular interaction (1, 21); the increased filling pressures remain detrimental because of the edema that results. In a canine model of advanced heart failure, sustained BAT decreased LV preload (Area_LVED and PLVED) (26). Experimental heart failure is associated with increased vascular capacitance and limb plethysmography in clinical heart failure has led to similar observations; the decrease in venous capacitance is related to the severity of failure (12). The redistribution of the venous reservoir due to increased sympathetic activity has been proposed as an aggravating mechanism for acute decompensated heart failure (10) and elevated filling pressures may predict outcomes regardless of LV ejection fraction (33). If the large capacitance-increasing effect of BAT can be sustained similar to observed sustained changes to heart rate and blood pressure (27), the effect may prove to be beneficial when venous capacitance is reduced in heart failure. The venous capacitance increase could work to decrease LV filling pressure and may also even increase LV preload and output by direct ventricular interaction (1, 21), in addition to BAT’s effects on arterial conductance.

Study limitations. First and foremost, it must be recognized that this was an acute study in anesthetized dogs. We have no data to comment on how anesthesia may have contributed to the relative effects on capacitance and conductance. We also have not titrated the current upwards to determine greatest achievable effects. Thus discussion of any implications of our results respecting heart failure and hypertension can only be speculative.

Second, the limitations of our application of the Brooksby-Donald method for estimating changes in abdominal venous capacitance must be understood. In their original description (6) the authors isolated the arterial and venous vessels perfusing the splanchnic viscera and demonstrated precise agreement between arterial inflow and venous outflow. This being true, integrating the difference gave an accurate measure of total blood volume accumulation or depletion. We compared aortic and caval flows at the diaphragm and equalized them by multiplying aortic flow by an average factor of 0.91 (SD = 0.22) to make it numerically equal to caval flow. The effects of this arbitrary equalization might have caused errors that accumulated with time. Therefore, we made no attempt to interpret total volume changes and focused only on the rate of change of volume during the first minute.

In addition to these limitations, we could not distinguish between changes in stressed or unstressed volume (25) because we did not measure venous pressure.

In this study, the currents of BAT were systematically chosen based on the drop in mean arterial pressure that they effected. The currents were not varied independently, as would be done to create a dose-response curve similar to what has been done with an earlier generation of the device (Rheos, CVRx) (13). For simplicity in our study, we only varied the stimulating current even though frequency and pulse width might have also been varied, as is done when the device is applied clinically (27).

Conclusions. Acute electrical activation of the carotid baroreflex by BAT decreases mean aortic pressure and heart rate, increases arterial conductance and venous capacitance, and reduces LV preload. The increase in capacitance during BAT was similar to that caused by an SNP dose that lowered blood pressure by a similar amount. Dilation of the vasculature by a substantial dose of SNP (in addition to anesthesia) does not attenuate the blood pressure-reducing effect of BAT. When blood pressure is increased by ANG II, BAT continues to be effective, with a current-dependent blood pressure reduction associated with increased venous capacitance and aortic conductance. The ability of baroreceptor activation to increase both venous capacitance and arterial conductance may be an important factor in applying this therapeutic intervention to treat patients with hypertension or heart failure.

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GRANTS

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DISCLOSURES

D. Georgakopoulos is the Principal Research Scientist at CVRx, Inc.

AUTHOR CONTRIBUTIONS

Author contributions: S.B., D.G., and J.V.T. conception and design of research; S.B. and D.G. performed experiments; S.B. analyzed data; S.B., D.G., I.B., and J.V.T. interpreted results of experiments; S.B. and J.V.T. prepared figures; S.B. and D.G. drafted manuscript; S.B., D.G., I.B., and J.V.T. edited and revised manuscript; S.B., D.G., I.B., and J.V.T. approved final version of manuscript.

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BAROREFLEX CONTROL OF CONDUCTANCE AND CAPACITANCE


