Effect of cardiac receptor stimulation on renal vascular resistance in the pregnant rat

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Hines, Tina, and William A. Herzer. Effect of cardiac receptor stimulation on renal vascular resistance in the pregnant rat. Am. J. Physiol. Regulatory Integrative Comp. Physiol. 278: R171–R178, 2000.—Stimulation of cardiac receptors (CR) evokes blunted reflex reductions in mean arterial pressure (MAP) in pregnant compared with virgin rats. Because CR-mediated sympathoinhibition has preferential effects on the kidney, we tested whether, during pregnancy, renal vascular resistance (RVR) changes less in response to CR stimulation and investigated possible mechanisms. MAP, right atrial pressure, renal sympathetic nerve activity (RSNA), renal blood flow (RBF), and RVR were measured in anesthetized animals in response to CR stimulation by graded atrial injections of saline. Baseline MAP and RVR and reflex changes in these variables during CR stimulation were reduced in late-pregnant vs. virgin rats (P < 0.05). Reflex changes in RSNA were attenuated in pregnant rats, but changes in RBF as a function of RSNA were similar in both groups. ANG II AT1-receptor blockade increased basal RBF more in virgin rats (P < 0.05), but between-group differences in reflex changes in MAP, RSNA, and RVR were maintained after AT1 blockade. Thus during CR stimulation, reflex changes in RVR were reduced in pregnant versus virgin rats. This difference does not appear to involve differential effects of ANG II.

renal blood flow; pentobarbital sodium; sympathetic nervous system; angiotensin II

PLASMA VOLUME INCREASES BY ~40–50% during human and rat pregnancy (2, 6, 14, 18). This increase reaches statistical significance during the first trimester of gestation and is strongly correlated with positive outcomes for mother and offspring (1, 13, 14, 26). Conversely, volume contraction is an ominous sign, present in pathologic conditions such as preclampsia and intrauterine growth retardation (6, 13, 14, 26). It appears, therefore, that an adequate increase in plasma volume is a critical adjustment of normal pregnancy. Mechanisms that initiate and maintain this early volume expansion are still not understood, but it has been shown that stimulation of volume-sensitive cardiac mechanoreceptors elicits attenuated reflex effects on blood pressure and renal function in the pregnant rat (18, 19, 24). Thus it seems that the sensitivity of this important volume regulatory mechanism, mediated by cardiac receptors (CR), is reduced during pregnancy and may contribute to the initiation and/or maintenance of an expanded blood volume. This alteration in neural control of hemodynamic function may confer on the pregnant female some degree of protection against the acute hypotension and diuresis that accompany significant blood volume expansion in the nonpregnant animal (12).

In a study of hemodynamic and neural responses to CR stimulation, it was demonstrated that bolus injections of saline into the right atrium evoked similar reflex renal sympathoinhibition but significant attenuation of the reflex depressor response in pregnant compared with virgin animals (18). Because it has been shown that CR stimulation has a preferential sympathoinhibitory effect on the renal circulation (4), these findings raised the possibility that the resistance vasculature of the kidney may change less for a given change in sympathetic nerve activity in pregnant versus virgin rats. Therefore, in the present investigation, we tested the hypothesis that in response to CR stimulation, renal vascular resistance (RVR) decreases less in pregnant compared with virgin rats. In addition, the elevated ANG II levels of pregnancy have been shown to play a larger role in supporting systemic vascular resistance (8, 9) and RVR in the anesthetized pregnant rat (3). Elevated ANG II levels could also contribute differentially to modulation of the effects of neurally released norepinephrine, both at baseline and in response to CR stimulation during pregnancy. Therefore, we investigated a possible role for ANG II in the renal vascular response to CR stimulation by repeating studies after blockade of the ANG II AT1-receptor subtype. Findings indicate that in the late pregnant compared with the virgin rat, acute CR stimulation, as indexed by increases in right atrial pressure (RAP), is associated with smaller changes in RSNA and RVR. For a given change in RSNA during CR stimulation, however, changes in RBF are identical to those in virgin rats. The smaller reflex reduction in RVR associated with CR stimulation does not appear to be due to a differential action of ANG II on AT1 receptors in the pregnant animal.

METHODS

All experimental procedures were conducted in accordance with the National Institutes of Health Guide for the Care and Use of Laboratory Animals as approved by the Council of the...
AT1-receptor antagonist L-158,809 (Merck, Rahway, NJ) was administered as needed (30-min intervals) to maintain a steady blood pressure and absence of withdrawal response to pinch of the hindpaw. Catheters were placed in a femoral artery and vein for measurement of blood pressure and drug infusions, respectively. Two catheters (PE-50) were inserted into the right atrium via the right external jugular vein for injection of saline used to stimulate cardiac receptors and for measurement of RAP. Correct placement of atrial catheters at the venoatrial junction was verified after experimentation. Animals received bilateral sinoaortic denervation as described previously (16) to eliminate reflex effects mediated by arterial baroreceptors. Absence of bradycardia and renal sympathoinhibition in response to a bolus injection of phenylephrine (5 mg/kg iv) was used as evidence of baroreceptor defferentiation. Through a left flank incision, the renal artery was isolated and fitted with a transit time 1-mm ultrasonic flow probe attached to a flowmeter (model T-206, Transonic Systems, Ithaca, NY), for measurement of renal blood flow (RBF). Postmortem blood flow was measured to verify a zero flow state. The accuracy and reliability of this technique for assessing RBF has recently been reported (29). A postganglionic renal sympathetic nerve bundle was isolated and suspended on a stainless steel bipolar electrode for recording of renal sympathetic nerve activity (RSNA), then secured in place using lightweight Silicon impression material (Coltene/Whaledent, New York, NY). The raw nerve signal was amplified (5,000–10,000×), filtered (300–3,000 Hz), fed to an audio monitor and a rectifying moving averager (10-ms time constant, CWE, Ardmore, PA), and, along with hemodynamic variables, displayed on a computer monitor (5,000-Hz sampling rate, Spike2, Cambridge Electronic Design, UK). Postmortem nerve activity was used as a zero reference for each animal and subtracted from averaged nerve activity.

Experimental Protocol

After a stabilization period of >30 min, cardiac receptors were stimulated by rapid (=0.5 s), intra-atrial injection of warmed 0.9% saline using randomly administered graded volumes (25, 50, 100, 150, 200, 250, 300 ml). Mean arterial pressure (MAP), RAP, RSNA, and RBF were recorded for 30 s before injections to obtain basal readings and for 90 s after injections to assess reflex effects and allow hemodynamics to return to baseline. Atrial injections were separated by 10 min. Cardiac receptors were stimulated by rapid (<0.5 s), intra-atrial injection of saline used to stimulate cardiac receptors and for measurement of RAP. Correct placement of atrial catheters at the venoatrial junction was verified after experimentation. Animals received bilateral sinoaortic denervation as described previously (16) to eliminate reflex effects mediated by arterial baroreceptors. Absence of bradycardia and renal sympathoinhibition in response to a bolus injection of phenylephrine (5 mg/kg iv) was used as evidence of baroreceptor defferentiation. Through a left flank incision, the renal artery was isolated and fitted with a transit time 1-mm ultrasonic flow probe attached to a flowmeter (model T-206, Transonic Systems, Ithaca, NY), for measurement of renal blood flow (RBF). Postmortem blood flow was measured to verify a zero flow state. The accuracy and reliability of this technique for assessing RBF has recently been reported (29). A postganglionic renal sympathetic nerve bundle was isolated and suspended on a stainless steel bipolar electrode for recording of renal sympathetic nerve activity (RSNA), then secured in place using lightweight Silicon impression material (Coltene/Whaledent, New York, NY). The raw nerve signal was amplified (5,000–10,000×), filtered (300–3,000 Hz), fed to an audio monitor and a rectifying moving averager (10-ms time constant, CWE, Ardmore, PA), and, along with hemodynamic variables, displayed on a computer monitor (5,000-Hz sampling rate, Spike2, Cambridge Electronic Design, UK). Postmortem nerve activity was used as a zero reference for each animal and subtracted from averaged nerve activity.

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Data Analysis

Heart rate was extracted from the peaks of the arterial pressure pulse, and baseline MAP, mean RAP, and mean HR values were measured in the 30 s prior to an atrial injection (1-s bins, Spike2, Cambridge Electronic Design). Reflex changes in these variables were measured by bracketing the maximum change following an intervention (=1 s) and calculating the mean value. Mean baseline RSNA was similarly derived from the averaged nerve activity in the 30 s preceding an injection. The change in nerve activity was averaged during the maximum change following a stimulus and was compared with the baseline value to calculate the percent change in RSNA. RVR was calculated as the ratio of MAP to RBF, and the mean baseline value was calculated as above. The change in RVR was calculated within the time interval that corresponded to the maximum reflex depressor response, although RBF, in most cases, continued to rise briefly before returning to baseline (see Fig. 1). Because differences in baseline values both before and after ANG II blockade may have influenced hemodynamic measurements, changes in MAP, HR, RAP, RBF, and RVR were expressed as percent change by analyzing the change in each variable relative to the 30-s baseline measurement immediately preceding the atrial injection. Changes in RAP in this report are expressed as absolute values, because percent changes in RAP can be quite large due to low (occasionally negative) baseline values.

Control Studies for Effects of Repeated Injections Over Time

Because repeated atrial injections were used in this study, control experiments were done to assess the effects of repeated atrial stimulation across time. In separate experiments in pregnant and virgin rats (n = 6 in each group), 10 intra-atrial injections were repeated every 10 min using the same standardized volume in each rat (1 ml/kg warmed saline) and reflex changes in MAP, HR, RSNA, and RBF were measured.

Statistical Analysis

Mean baseline hemodynamic values before and after AT1 receptor blockade were compared between groups by analysis of variance. Changes in all variables in response to graded atrial saline injections as well as data from time-control experiments were compared between groups using a two-factor repeated-measures analysis of variance with post hoc comparisons using the Student-Newman-Keuls test. Correlations between variables were calculated and compared between groups using multiple regression analysis (Statistica, StatSoft). All regression lines were forced through zero. A P value of <0.05 was considered significant. Results are presented as means ± SE

RESULTS

Baseline Hemodynamics in Pregnant and Virgin Rats

Table 1 illustrates mean baseline hemodynamic measurements in pregnant and virgin rats before and after ANG II AT1 receptor blockade. In the intact control state, resting MAP and RVR were significantly lower in late-pregnant compared with virgin rats (P < 0.05). Baseline RAP was increased in intact pregnant compared with virgin animals, but this difference was not statistically significant (P = 0.055). Basal levels of RBF and HR were similar in the two groups.

Effect of cardiac receptor stimulation in the intact animal. An original trace of experimental data from a virgin rat is shown in Fig. 1. In response to a 250-µl
saline injection at the arrow, RAP increased transiently. This stimulus was associated with an immediate and transient inhibition of RSNA. The atrial injection produced a slightly delayed increase in arterial pressure as the volume bolus entered the circulation. Cardiac receptor stimulation was also associated with a rise in RBF and a reflex reduction in MAP and HR.

Increases in mean RAP were used in this study as an index of the stimulus intensity to CR. As demonstrated previously (18) and in this study, increases in RAP in response to atrial injections were significantly larger in pregnant rats (Fig. 2A), and, for this reason, reflex changes in all other variables are illustrated as a function of changes in RAP. Also similar to previously reported data (18), reflex decreases in MAP in response to the RAP stimulus were attenuated in pregnant compared with virgin animals (P < 0.05, Fig. 2B) despite the larger changes in RAP in the pregnant group.

The slope of the relationship between increases in RAP and reflex decreases in RSNA was significantly attenuated in this study in pregnant compared with virgin rats (P = 0.05, Fig. 3A), although the maximum reflex reduction in RSNA was similar in both groups. The correlation between changes in HR and changes in RAP also tended to be blunted in pregnant compared with virgin rats, but this difference was not statistically significant (P = 0.09, Fig. 3B).

The relationship between increases in RAP and changes in RBF was variable, particularly in pregnant

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<th>MAP, mmHg</th>
<th>RAP, mmHg</th>
<th>HR, beats/min</th>
<th>RBF, ml/min</th>
<th>RVR, mmHg·ml⁻¹·min⁻¹</th>
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<tr>
<td>Virgin (n = 9)</td>
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<td>Control</td>
<td>124.3 ± 2.1</td>
<td>0.8 ± 0.3</td>
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<td>Blockade</td>
<td>110.6 ± 2.6*</td>
<td>1.5 ± 0.3</td>
<td>404.7 ± 3.9</td>
<td>7.4 ± 0.3*</td>
<td>16.3 ± 0.9*</td>
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<tr>
<td>Control</td>
<td>100.4 ± 4.1†</td>
<td>1.8 ± 0.5</td>
<td>411.3 ± 5.1</td>
<td>5.1 ± 0.2</td>
<td>25.0 ± 0.7†</td>
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<tr>
<td>Blockade</td>
<td>88.3 ± 3.1*†</td>
<td>3.2 ± 1.0</td>
<td>396.2 ± 4.4</td>
<td>6.0 ± 0.4*†</td>
<td>14.5 ± 0.9*</td>
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Values are means ± SE. *P < 0.05 compared with intact (control) animals in same group. †P < 0.05 compared with virgin in either control or blocked state. MAP, mean arterial pressure; RAP, right atrial pressure; HR, heart rate; RBF, renal blood flow; RVR, renal vascular resistance.
rats (Fig. 4A). Consistent with the reflex changes in RSNA associated with CR stimulation in pregnant rats, there was a trend for blunted changes in RBF, although this difference was not statistically significant (P = 0.12). The linear fit between RBF and RAP was not significant in the pregnant rats (P = 0.133). The slope of the relationship between RVR and RAP was significantly blunted in pregnant versus virgin rats (P < 0.05, Fig. 4B).

To more directly assess the relationship between reflex renal sympathoinhibition and renal hemodynamics, changes in RBF and RVR were plotted as a function of the change in RSNA (Fig. 5). The reflex decreases in RSNA associated with CR stimulation were similarly correlated with changes in RBF (Fig. 5A) and changes in RVR (Fig. 5B) in both groups of animals. The linear correlation between RBF and RSNA was not significant in pregnant rats (P = 0.09).

Although rats had undergone bilateral sinoaortic denervation to remove reflex effects arising from arterial baroreceptors, atrial injections were associated with transient pressor effects that may evoke differential autoregulatory responses in the two groups. We tested this possibility by comparing the relationship between this transient increase in blood pressure and changes in RBF. The slopes of this relationship did not differ from zero in the absence of arterial baroreflex control and did not differ between groups (virgin = 0.008 ml·min⁻¹·mmHg⁻¹; pregnant = 0.006 ml·min⁻¹·mmHg⁻¹, NS), indicating similarly effective autoregulation, as has been reported by others (25).

**Effect of Cardiac Receptor Stimulation After ANG II AT₁-Receptor Blockade**

To investigate a role for ANG II in the altered RVR response to CR stimulation in pregnant rats, atrial saline injections were repeated after blockade of the ANG II AT₁-receptor subtype. As outlined above, 20 min after ANG II AT₁-receptor blockade, RBF increased and RVR and MAP decreased significantly in both groups of animals (P < 0.05, Table 1). RBF increased slightly but significantly more in virgin than in pregnant rats in response to ANG II blockade (P < 0.05), resulting in similar resting levels of RVR after blockade in the two groups. AT₁-receptor blockade had no significant effect on mean RAP or mean HR in either group, although RAP tended to increase in both groups. Compared with preblockade baseline values, resting RSNA also re-

![Image](http://ajpregu.physiology.org/Downloadedfromhttp://ajpregu.physiology.org/)
mained unchanged in both groups after ANG II blockade (decrease of 4.5 ± 0.12% in virgin; increase of 5.0 ± 0.22% in pregnant rats, not significant).

In response to CR stimulation, increases in RAP and reflex changes in HR were not affected by ANG II-receptor blockade either in magnitude or in difference by group (data not shown). Thus the larger changes in RAP evoked by atrial injections in pregnant rats persisted after ANG II blockade. Figure 6 illustrates the correlation between changes in RAP and reflex changes in MAP (A) and RVR (B) in rats with ANG II blockade. Similar to observations before ANG II receptor blockade, relationships between RAP and MAP and RVR were attenuated in pregnant compared with virgin rats (P < 0.05). The magnitude of the decreases in MAP and RVR was reduced in both groups after ANG II blockade, presumably due to lower postblockade baseline values for these variables. Also similar to preblockade measurements, the correlation between RSNA and RAP was shifted to the right in pregnant compared with virgin animals after ANG II AT1-receptor blockade, but the difference between groups after blockade was not significant (P = 0.13, Fig. 7A). In virgin animals, the relationship between RSNA and RAP did not show a significant linear fit (P = 0.23). When changes in RBF were correlated with changes in RSNA during CR stimulation in animals with ANG II blockade, there was also no difference between groups (Fig. 7B); however, the correlation between RBF and RSNA in pregnant animals showed a significant linear relationship after ANG II blockade (P < 0.05).

Time-Control Studies

To ensure that repeated stimulation of CR with atrial saline injections did not result in desensitization of the receptors or otherwise influence results, 10 injections (1 ml/kg) were repeated at 10-min intervals in separate groups of pregnant and virgin animals (n = 6 each group). Reflex changes in MAP, HR, RBF, and RSNA were similar across time in both groups (data not shown). For example, the average decreases in RSNA after the first and tenth injections were as follows: pregnant = 65.48 ± 1.89% (1st); 69.16 ± 2.42% (10th); virgin = 63.12 ± 2.24% (1st); 62.91 ± 3.15% (10th).

DISCUSSION

This study has demonstrated that CR stimulation, as indexed by increases in mean RAP, is associated with attenuated reflex reductions in MAP, RSNA, and RVR in

Fig. 4. Correlation between change in RAP and %change in renal blood flow (RBF; A) and renal vascular resistance (RVR; B) during cardiac receptor stimulation in pregnant and virgin rats. In A, pregnant (slope = 0.53 ± 0.4, r² = 0.21); virgin (slope = 0.95 ± 0.5, r² = 0.36); not significant between groups. In B, pregnant (slope = −1.12 ± 0.7, r² = 0.41); virgin (slope = −3.60 ± 1.1, r² = 0.72); *P = 0.044 compared with virgin.

Fig. 5. Correlation between %change in RSNA and %change in RBF (A) and %change in RVR (B) during CR stimulation in pregnant and virgin rats. In A, pregnant (slope = 0.021 ± 0.02, r² = 0.12); virgin (slope = 0.037 ± 0.02, r² = 0.37); not significant between groups. In B, pregnant (slope = −0.05 ± 0.04, r² = 0.23); virgin (slope = −0.07 ± 0.04, r² = 0.39); not significant between groups.
late-pregnant compared with virgin rats. In contrast, for a given change in RSNA, RBF changed similarly in both groups of animals during CR stimulation.

The findings of this study differ slightly from a previous report using a similar stimulation protocol (18). In the earlier study, similar changes in RSNA were observed in response to atrial saline injections in pregnant compared with virgin rats when data were plotted as a function of the volume injected. Although there was a tendency for an attenuated sympathoinhibitory response in pregnant rats, when data were plotted as a function of the change in RAP, the difference was not significant in the previous report. In the present study, the attenuated sympathoinhibition in pregnant rats did reach statistical significance, most likely due to the larger changes in RAP that were evoked in this study. It is unclear why atrial injections of similar volumes would evoke such a wide range of atrial pressures, but we have observed marked variability in atrial pressures both at baseline and during injections. In addition, the animals reported previously were more extensively instrumented, which may have altered hemodynamics. Studies in nonpregnant rats have described two classes of atrial receptors with low- and high-pressure thresholds for activation (22, 28). The fact that the apparently larger afferent stimulus, as indexed by RAP in this study, was associated with attenuated reflex effects in the pregnant rat suggests some gestational alteration in afferent signal transduction that could include increased pressure levels for activation. Alternatively, it may be that RAP is not a reliable index of atrial stretch. For example, the larger changes in RAP in pregnant rats in response to similar volume loads in both groups could be due to a reduction in atrial compliance during pregnancy, a condition that would reduce atrial stretch and, therefore, presumably CR afferent activity. Available evidence, however, indicates that atrial compliance is probably not changed in the pregnant rat (19), and the larger changes in RAP in this study may simply reflect addition of relatively large atrial volumes to an already expanded plasma compartment. Clearly afferent CR recordings are needed to resolve this issue, and preliminary data from this laboratory indicate that there are gestational alterations in CR afferent activity (17). By whatever mechanism, however, CR stimulation during pregnancy is associated with attenuated reflex changes in RSNA and RVR.

Fig. 6. Correlation between change in RAP and %change in MAP (A) and RVR (B) during CR stimulation in pregnant and virgin rats after ANG II blockade. In A, pregnant (slope = −0.89 ± 0.4, r² = 0.68); virgin (slope = −1.13 ± 0.5, r² = 0.46); *P = 0.048 compared with virgin. In B, pregnant (slope = −0.96 ± 0.4, r² = 0.59); virgin (slope = −2.89 ± 0.9, r² = 0.76); *P = 0.039 compared with virgin.

Fig. 7. Correlation between change in RAP and %change in RSNA (A) and between %change RSNA and %change RBF (B) during CR stimulation in pregnant and virgin rats after ANG II blockade. In A, pregnant (slope = −10.11 ± 4.3, r² = 0.41); virgin (slope = −20.33 ± 8.4, r² = 0.21); not significant between groups. In B, pregnant (slope = −0.021 ± 0.1, r² = 0.52); virgin (slope = −0.026 ± 0.02, r² = 0.49); not significant between groups.
Despite the attenuated reduction in RSNA in pregnant compared with virgin rats during CR stimulation, RBF increased and RVR decreased similarly in the two groups for a given change in RSNA. Thus the effector response to CR stimulation does not appear to be altered in the pregnant compared with the virgin rat, suggesting similar responsiveness to sympathetic withdrawal in the two groups. Due to the correlative nature of the data analysis in this study, however, the causal relationship between changes in RSNA and changes in RBF and RVR during CR stimulation cannot be determined, and changes in renal hemodynamics may have been related to other factors such as atrial natriuretic peptide or nitric oxide release or renal autoregulation. RBF was similar in pregnant and virgin rats at baseline data that are in accord with many reports (7, 10, 25), suggesting a return toward prepregnant values from the significantly larger RBF that has often been reported during midgestation in the rat (7, 25). Whether differences in the correlation between RSNA and RBF might be detected at midgestation remains to be investigated.

Angiotensin AT₁-receptor blockade was used in this study to determine whether differential support of renal hemodynamics in pregnant compared with virgin rats by ANG II could contribute to the attenuated change in RVR during CR stimulation. Baylis and Collins (3) reported larger changes in renal hemodynamics and MAP after saralasin and captopril administration in anesthetized pregnant compared with virgin rats. Similarly, Crandall and Heesch (9) reported a greater decrease in MAP in anesthetized pregnant compared with virgin rats after ANG II blockade with captopril, indicating a larger contribution of ANG II to vascular resistance in the gravid animals. In conscious rats, ANG II blockade with captopril and saralasin has evoked similar (3, 23) or only modestly larger (8) decreases in MAP in pregnant compared with virgin rats. Blockade of ANG II AT₁ receptors in this study resulted in significant decreases in baseline MAP and RVR and a significant increase in RBF in both groups of animals. The increase in RBF in virgin rats was slightly larger compared with that in pregnant animals, a finding that removed the baseline difference in RVR in the two groups after ANG II blockade. These data indicate that ANG II acting on the AT₁-receptor subtype has a similar effect on MAP in both anesthetized pregnant and virgin animals and has a greater effect on renal hemodynamics in virgin rats. The effects of ANG II blockade reported here contrast others previously cited (3, 9). Rats in the current study had been subjected to arterial baroreceptor denervation, and the acute effects of this procedure could have affected the renin-angiotensin system and/or sympathetic outflow differentially in the two groups. In addition, the use of a specific AT₁-receptor blocker in this study contrasts the use of a converting enzyme inhibitor or saralasin in previous studies and may contribute to our findings. The fact that RSNA did not change in response to the decrease in MAP evoked by AT₁-receptor blockade in either group not only validates the removal of baroreceptor input, but may have contributed to the subsequent changes in renal hemodynamics that were associated with CR stimulation. Others have shown that ANG II blockade with either captopril (9) or AT₁-receptor antagonists (27) increases resting RSNA in baroreflex intact animals.

In summary, activation of volume-sensitive CR in the late-pregnant compared with virgin rats was associated with a significant blunting of the relationships between increased RAP and reflex reductions in MAP, RSNA, and RVR. These findings support the concept that activity in this reflex pathway is attenuated during gestation. At the level of the effector organ, however, RBF and RVR changed equivalently for a given change in RSNA during CR stimulation in both groups of animals, suggesting that the alterations observed in reflex function most likely involve the afferent and/or central limbs of this regulatory pathway. The differences that were noted between pregnant and virgin rats during CR stimulation did not appear to be mediated by the effects of ANG II acting on AT₁ receptors. Indeed, ANG II blockade had larger effects on resting RBF in baroreceptor denervated virgin rats.

Perspectives

A picture is emerging of a generalized reduction in the sensitivity of autonomic neural reflexes during pregnancy. Observations by Heesch and Rogers (15), Masilamani and Heesch (21), and Brooks et al. (5) support the concept that reflex effects mediated by arterial baroreceptors are attenuated in pregnant rats, rabbits, and dogs. Previous findings from this lab and others (18, 19, 24) as well as the present study extend this gestational alteration to cardiac mechanoreceptors. Mechanisms involved in the blunted activity of these pathways are being elucidated. Heesch and Rogers (15) and Deng and Kaufman (11) have provided evidence for central blunting of arterial and cardiac baroreflexes, respectively. More data are needed concerning possible alterations in afferent nerve activity from cardiac receptors and arterial baroreceptors during pregnancy. The present study indicates that peripheral effector mechanisms in the kidney, at least as they relate to the relationship between RSNA and RBF, may not be markedly altered during pregnancy. It is important to keep in mind that the acute stimuli that have been used to study changes in autonomic regulation may not fully elucidate the changes that occur due to the chronic stimulus that pregnancy imposes. Thus further investigation is needed to determine the precise mechanisms for these changes in autonomic regulation during pregnancy, but it does appear that the profound cardiovascular adjustments of pregnancy are accompanied by changes in neural control that help to minimize perturbations around new gestational set points.

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