THE HEMODYNAMICS IN FEMALE SPONTANEOUSLY HYPERTENSIVE RATS (SHR)

IVAN ALBRECHT

A comparison of the hemodynamics in six months old female SHR and normotensive ones, on the basis of cardiac output, heart rate, blood pressure and organ blood flow data is presented. Compared to the normotensive rats the SHR showed highly elevated values of systolic, diastolic and mean blood pressures, lower values of the heart rate, and cardiac output but elevated total peripheral resistance. Distribution of the cardiac output was nearly equale in normotensive and SHR except the heart, where the flow-fraction was nearly doubled. Considerable differences were found in organ flows if expressed as in ml per 1g of tissue. Skeletal muscle, uterus, thyroid gland and kidneys have lower blood supply in SHR.

There is relatively little information available on the hemodynamics of spontaneously hypertensive rats (SHR). Folkow reported hemodynamic studies of regional vascular beds in SHR. There is some further information on hemodynamics in 50 day-old SHR reported by Albrecht based on the cardiac output estimation. Because of this lack of informations, in the present study SHR, which seem to provide the best animal model of human essential hypertension, have been used to obtain some basic data about the cardiac output and organ blood flows.

MATERIALS AND METHODS

Female SHR of the 23rd-24th generation of the Okamoto-Aoki strain (2nd-3rd generation born in our laboratories) were investigated at the age of 6 months. The animals were anaesthetized with 100 mg/kg of Inactin and blood pressure was measured in the carotid artery by means of canula connected to an Elema-Schönander pressure transducer, electromanometer and minograph recorder. Values of systolic, diastolic and mean blood pressures and heart rate were read off from the minograph record. Cardiac output was estimated by a dye dilution technique using Evans blue as the indicator. Organ blood flows were estimated on the basis of the distribution of intravenously injected $^{86}$Rb (20 uC in 20 ul). Control animals consisted of normotensive female rats of the same age.

RESULTS

Fig. 1: Upper section of the graph - on the left are the values of systolic (SP), mean (MAP) and diastolic (DP) blood pressures for SHR and corresponding values of blood pressures in the normotensive controls (NR) in the lower part of the graph. All pressure values were higher in SHR than in controls. Pulse pressure (PP) was also significantly higher in SHR, but bradycardia was noted in this group of SHR at the age of 6 months.

Fig. 2: At the same age SHR showed a lower body weight than normotensive controls and this difference was significant. Cardiac output in SHR was also lower than NR and this difference expressed in ml/100 g of body weight was also significant. Values of total peripheral resistance were very high in the fully developed hypertension and the differences from control animals were highly significant.

Fig. 3: The distribution of cardiac output expressed as a percentage of blood flow supplied...
Fig. 1. Blood pressure and heart rate in spontaneously hypertensive (SHR) and normotensive (NR) rats. (For explanation see text). Each value shows mean ± S.D. Figures (0.01, 0.05) between SHR and NR show statistical differences (p < 0.05).

NR and SHR Females
Age: 6 m

Cardiac Output

Fig. 2. Cardiac output, stroke volume, total peripheral resistance and body weight in spontaneously hypertensive (SHR) and normotensive rats (NR). (For other legends, see Fig. 1.)
Fig. 4. Blood flow (in ml/1g of tissue) in thyroid gland, heart, kidney, gastrointestinal tract, uterus, muscle and skin, in spontaneously hypertensive (SHR) and normotensive (NR) rats. (NS: not significant difference, for other legends, see Fig. 1.)

Fig. 3. Distribution of the cardiac output (in %) to thyroid gland, heart, gastrointestinal tract, uterus and kidneys.

(NS: not significant difference, for other legends, see Fig.1.)
to various organs was the same in SHR and NR for the thyroid gland, kidney, and gastro-intestinal tract. There is a slight but insignificant decrease of cardiac output fraction to the uterus in SHR. The very high fraction of cardiac output to the myocardium in SHR was in proportion to the hypertrophy of this organ at the hypertensive stage.

Fig. 4: Blood flow in ml/g myocardium was equal in SHR and NR. The SHR had, however, significantly lower blood flows to skeletal muscle and the uterus. The significant decrease in absolute flow to the thyroid gland can be ascribed to lower values of cardiac output in SHR. Under the given experimental conditions skin blood flow values showed a high degree of scatter, but mean flows were the same in SHR and NR.

DISCUSSION

1. These results give some initial data on the haemodynamics of SHR. High values of diastolic blood pressure seemingly due to the high frequency of heart rate in rats are not common in human hypertension.

2. The high values of pulse pressure and bradycardia in SHR may indicate that reflex regulation of the heart through carotid reflexes is functioning adequately.

3. Decreased values of cardiac output and increased values of total peripheral resistance in SHR was found in female rats with fully developed chronic hypertension.

4. The low values of muscle blood flow in SHR may be related to the lower degree of physical activity observed in these animals at this particular age.

5. Low uterine blood flow values may be related to the low rearing performance in SHR at the age over 6 months. The slightly lower renal blood flow in SHR may be related to the fact that some individuals showed initial nephrosclerosis.

REFERENCES
