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Blood Volume, Cardiac Size and Renal Function in Dogs with Hypertension Produced by Goldblatt Technic.

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Freeman and Page¹ found no significant changes in plasma volume during a period of hypertension experimentally produced by the Goldblatt technic,² in 3 dogs, 2 of which were completely sympathectomized. We have followed the changes in plasma, cell and total volume by the dye method of Gibson and Evans^{3, 4} in 5 female dogs, none of which were sympathectomized, during periods of hypertension produced by the Goldblatt technic, varying from 1 to 10 months, in an attempt to correlate observed changes in blood volume with changes in mean arterial pressure, renal function and cardiac size as determined by X-ray.

Control mean arterial pressure was established by an average of 12 determinations by femoral puncture over a period of 1 month prior to operation. In the operative procedure the renal artery clamp was completely closed and then released 1 to 1½ turns. Constriction of the right renal artery was effected in each animal first, followed by constriction of the left renal artery at a subsequent operation 2 weeks later. Recovery from the surgical procedure was uneventful in all except Dog 23 in which, following the constriction of the left renal artery uremia developed. Following the complete release of the clamp on the left renal artery this animal survived but a chronic azotemia persisted.

Renal function was estimated by determinations of phenolsulphonephthalein excretion and blood urea nitrogen.

Results are summarized in Table I.

Control mean arterial blood pressures were normal in all dogs. Following constriction of the right renal artery, there was no change in pressure in 1 dog, a transient rise in 1 dog and sustained increase of from 30 to 50 mm Hg in 3 dogs.

In the 4 dogs in which both renal arteries were constricted, pres-

¹ Freeman, N. E., and Page, I. H., *Am. Heart J.*, 1937, **14**, 405.

² Goldblatt, H., Lynch, J., Hanzal, R. F., and Summerville, W. W., *J. Exp. Med.*, 1934, **59**, 347.

³ Gibson, J. G., 2d, and Evans, W. A., Jr., *J. Clin. Invest.*, 1937, **16**, 301.

⁴ Gibson, J. G., 2d, Keeley, J. L., and Pijoan, M., *Am. J. Physiol.*, 1938, **121**, 800.

TABLE I.
Plasma, Cell and Total Blood Volume, Mean Arterial Tension and Renal Function in Dogs Rendered Hypertensive by the Goldblatt Technic.

| Date | Wt, kg | Blood Volume | | | | | | Hematocrit mm Hg | P.S.P. % | B.U.N. mg % | Remarks |
|---------|--------|--------------|-----------|------|-----------|-------|-----------|------------------|----------|-------------|----------------------------|
| | | Plasma | | Cell | | Total | | | | | |
| | | cc | cc per kg | cc | cc per kg | cc | cc per kg | | | | |
| 3/25/37 | 17.4 | 998 | 57.2 | 657 | 37.7 | 1655 | 95.1 | 39.9 | 60 | 16 | Right renal artery clamped |
| 4/13 | | | | | | | | | | | |
| 4/22 | | | | | | | | | | | |
| 5/4 | | | | | | | | | | | |
| 9/27 | 16.4 | 1105 | 67.3 | 1080 | 65.8 | 2185 | 133.1 | 49.4 | 65 | 60 | Left |
| 10/19 | 17.2 | 1268 | 73.7 | 1127 | 65.5 | 2395 | 139.3 | 47.03 | 60 | 60 | |
| 11/30 | 18.0 | 947 | 52.6 | 928 | 51.5 | 1875 | 104.3 | 49.6 | 195 | | |
| 7/27 | 15.3 | 850 | 55.5 | 695 | 45.4 | 1545 | 101.0 | 45.9 | 85 | 16 | Right |
| 8/23 | | | | | | | | | | | Left |
| 8/30 | | | | | | | | | | | |
| 9/2 | | | | | | | | | | | |
| 10/13 | 14.4 | 1063 | 73.9 | 722 | 50.1 | 1785 | 124.0 | 40.4 | 85 | 15 | Right |
| 11/30 | 13.1 | 772 | 58.7 | 848 | 64.7 | 1620 | 123.5 | 52.4 | 80 | 18 | Left |
| 1/12 | 15.2 | 986 | 64.8 | 829 | 54.5 | 1815 | 119.4 | 45.7 | 80 | 16 | |
| 5/12 | 18.0 | 1120 | 62.2 | 1130 | 62.2 | 2250 | 125.0 | 50.3 | 75 | 14 | |
| 7/27 | 20.0 | 1005 | 50.3 | 1530 | 76.5 | 2535 | 126.8 | 60.2 | 70 | 16 | Right |
| 8/26 | | | | | | | | | | | Left |
| 9/2 | | | | | | | | | | | |
| 9/6 | | | | | | | | | | | |
| 9/10 | 21.8 | 1100 | 50.5 | 1440 | 66.0 | 2550 | 117.0 | 56.8 | 70 | 26 | |
| 10/18 | 19.6 | 1070 | 54.7 | 1470 | 75.0 | 2540 | 129.5 | 57.7 | 75 | 21 | |
| 11/15 | 21.0 | 1093 | 52.0 | 1277 | 60.8 | 2370 | 113.0 | 54.0 | 75 | 15 | |
| 11/23 | 21.3 | 1025 | 48.2 | 1065 | 50.0 | 2090 | 98.0 | 50.8 | 75 | — | |
| 1/11 | 23.4 | 953 | 40.7 | 1297 | 55.9 | 2250 | 96.2 | 57.6 | 70 | 18 | |
| 5/12 | 23.2 | 1320 | 56.9 | 1040 | 44.8 | 2360 | 101.5 | 44.0 | 70 | 15 | |

pressure rose on an average of 85 mm Hg above the control level. There was a gradual decline over a 3 to 6 months' period to levels of about 175 mm Hg, which were thereafter sustained throughout the course of the observation period. In Dog 39, following constriction of the right renal artery only, pressure rose from 110 to 170 mm Hg, ranged between 155 to 175 mm Hg for a month and following right nephrectomy fell promptly to the control level; and remained within normal limits thereafter.

Absolute plasma volume fluctuated throughout the period of observation, increases ranging from 160 to 270 cc and decreases of from 50 to 230 cc. In 4 dogs the total volume of red cells increased in 3 and decreased in 1, as did total blood volume. While these fluctuations were considerable, they bore no apparent relationship to the degree or duration of elevation of mean arterial pressure. In Dog 39, in which the period of pressure elevation was accompanied by a decrease in plasma and total volume, removal of the ischemic kidney produced a prompt return of mean arterial pressure to normal, and the blood volume rose to the control level simultaneously.

There was definite cardiac hypertrophy as shown by X-ray in the 4 dogs undergoing bilateral constriction of the renal arteries, the transverse diameter having been increased on an average of 1.4 cm and the diagonal measurement by 1.6 cm. None of these animals showed any signs or symptoms of congestive heart failure.

Renal function was unimpaired, both blood urea nitrogen and phenolsulphonephthalein excretion being within normal limits throughout the period of observation in 4 dogs. In Dog 23, in which uremia and subsequent azcemia developed, the blood urea nitrogen remained elevated and phenolsulphonephthalein excretion diminished.

During the period of hypertension no constant trend in the course of the blood volume was observed. While the volume was increased in some animals, the finding of a decrease in volume during the period of hypertension in others would seem to indicate that the elevation in pressure was not dependent upon an increase in the total amount of circulating blood.

While all animals developed cardiac hypertrophy, congestive failure did not occur, and in only 1 animal (Dog 34) was there an increase in total blood volume of the degree associated with congestive heart failure in humans.⁵

No anemia, even in the dog suffering from azotemia, occurred.

The observed fluctuations in blood volume were greater than those found by Freeman and Page¹ in sympathectomized dogs.

⁵ Gibson, J. G., 2d, and Evans, W. A., Jr., *J. Clin. Invest.*, 1937, **16**, 851.