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Polycythemia of Morbus Caeruleus (Cyanotic Type of Congenital Heart Disease.)

PHILLIP HALLOCK. (Introduced by C. J. Watson.)

From the Division of Internal Medicine, University of Minnesota Hospitals, Minneapolis, Minn.

The polycythemia of morbus caeruleus is similar in many respects to that of the primary form (polycythemia vera), yet from an etiological point of view it differs a great deal. In both forms the red cell counts and hemoglobin concentrations are increased and the hematocrit readings are high. Blood volume studies have revealed that the total blood volume and circulating red cell mass are considerably elevated in polycythemia vera while the plasma volume remains essentially unaltered.[1, 2, 3] While it is repeatedly stated that the total blood volume and red cell mass are elevated in the polycythemia of morbus caeruleus, these assertions are based not on actual blood volume determinations but on inferences drawn first, from the fact that the red cell counts and hemoglobin concentrations are high, and second, from the assumption that morbus caeruleus is similar to other forms of secondary polycythemia which arise from oxygen deficiency. Extremely meager information is available concerning the status of total blood volume, circulating red cell volume, and plasma volume in morbus caeruleus. The first case of morbus caeruleus in which total blood volume was measured and in which an attempt was made to estimate the plasma volume was that reported by Parkes-Weber and Dorner.[4] In this case of morbus caeruleus the total blood volume, as determined by Haldane and Smith's[5] carbon monoxide method, was found to be increased. The plasma volume was determined indirectly and considered to be normal from the estimation of the concentration of the dry residue in the blood serum. One year previous to this, however, Bie and Maar[6] had studied the concentration of plasma in 2 cases of morbus caeruleus by similarly estimating the concentration of the dry residue in the serum. They concluded that there was no significant change in plasma volume concentration

1 Rowntree, L. G., and Brown, G. E., *The Volume of Blood and Plasma in Health and Disease*, W. B. Saunders Co., Philadelphia, 1929.

2 Lampe, W., *Deutsche Med. Wchnschr.*, 1925, **51**, 2025.

3 Gibson, J. G., Harris, A. W., and Surgert, V. W., *J. Clin. Invest.*, 1938, 18.

4 Parkes-Weber, F., and Dorner, G., *Lancet*, 1911, **180**, 150.

5 Haldane, and Smith, L., *J. Physiol.*, 1900, **25**, 33.

6 Bie, W., and Maar, W., *Deutsches Arch. fur Klin. Med.*, 1910, **44**, 382.

and that the increased cell count was not, therefore, due to diminution in plasma volume. Blumenfeldt and Wolheim,[7] using trypan red dye estimated the blood volume in a 20-year-old girl with cyanotic type of heart disease. The plasma volume was markedly diminished, namely, 690 cc (13.4 cc per kg). The total blood volume was 3,028 cc or 59.1 cc per kg. Meyer,[8] in a study of the hemodynamics of the circulation in a 22-year-old male having Tetralogy of Fallot, estimated the plasma volume by means of the Congo red method and found it to be exceedingly low (755 cc or about 16 cc per kg). The total blood volume was 4,100 cc, or about 86 cc per kg, which is within normal limits.

In the present investigation, 4 cases of morbus caeruleus have been studied with respect to total blood volume, circulating red cell volume and plasma volume. The subjects were adults, 3 males and one female, all of whom had veno-arterial shunts as evidenced by the marked cyanosis. Their cardiac status was carefully studied by physical examination and by fluoroscopic and electrocardiographic examinations of the heart. The oxygen content and capacity were determined by arterial puncture and in every instance oxygen unsaturation was increased. The "Evans Blue" dye was employed in determining plasma volume following the method described by Gibson.[9] The dye concentration in the serum was determined with a Marten's spectrophotometer.

Results. It will be noted (Table I) that the hematocrit values are extremely high when it is remembered that the normal range is 45 to 50% for males and 40 to 45% for females. The highest value, 83%, recorded in this series was in a male of 18 years of age who was believed to have Tetralogy of Fallot. The lowest value, 72%, was obtained in a female 37 years of age who suffered from the same anomaly. The most striking feature (Table I) was the low absolute plasma volumes which were consistently found in all 4 cases. The lowest plasma volume (27.6 cc per kg) was obtained in the third case, a male 33 years of age. The average plasma volume in the 4 cases was 30 cc per kg.

The circulating red cell mass and total blood volume were found to be elevated in each instance.

In Table II we have compared the results obtained in morbus caeruleus with those of normal individuals and those with primary polycythemia (polycythemia vera). It will be noted that in morbus

7 Blumenfeldt, E., and Wolheim, E., *Klin. Wschr.*, 1927, **6**, 396.

8 Meyer, P., *Z. fur Klin. Med.*, 1932, **120**, 341.

9 Gibson, J. G., *J. Clin. Invest.*, 1937, **16**, 301.

TABLE I.
Blood Findings in Morbus Caeruleus (Cyanotic Type of Congenital Heart Disease).

	Age	Sex	Wt, kg	Hgb. % 17 g 100%	R.B.C. per mm³ (Mill.)	Hemato-crit (Vol.%)	Blood volume: Plasma vol. liters	Blood volume: Red cell vol. liters	Blood volume: Total Blood vol. liters	Blood vol. per kg: Plasma vol. cc	Blood vol. per kg: Red cell vol. cc	Blood vol. per kg: Total vol. cc	% deviation from normal volume: Plasma	% deviation from normal volume: Red cell	% deviation from normal volume: Total
K.C.	18	M	60.0	126	9.04	83	1.77	8.63	10.4	29.5	144.0	173	—36	+230	+90
A.N.	37	F	67.5	133	10.8	72	1.98	5.02	7.0	29.3	74.5	104	—25	+100	+46
I.W.B.	33	M	59.8	128	6.8	74	1.65	4.95	6.6	27.6	82.8	110	—41	+ 92	+22
H.F.	43	M	45.5	137	6.5	73	1.54	4.16	5.7	33.9	91.5	125	—28	+110	+39
										30.0 avg	98.2 avg	128 avg			

K.C. = Tetralogy of Fallot.
A.N. = " " "
I.W.B. = Patent ductus arteriosus with patent interventricular septal defect.
H.F. = Infundibular stenosis with interventricular septal defect.

TABLE II.
Comparison of Blood Volume in Morbus Caeruleus (Cyanotic Type of Congenital Heart Disease) to That in Polycythemia Vera and in Normal Individuals.

	Plasma volume cc per kg	Red cell volume cc per kg	Total blood volume cc per kg
	Females		
Normal (avg of 10 normals)	39.0	32.0	70.8
Morbus caeruleus	29.3	74.5	104.0
Polycythemia vera (avg of 6 cases)	76.7	177.0	253.7
	Males		
Normal (avg of 10 normals)	46.4	43.1	89.5
Morbus caeruleus (avg of 3 cases)	30.3	109.0	136.0
Polycythemia vera (avg of 6 cases)	51.2	145.0	196.2

caeruleus the plasma volume is 29.3 cc per kg as compared to the mean normal of 39 cc per kg for females and 30.3 cc per kg as compared to a mean normal of 46.4 cc per kg for males. This represents a subnormal diminution of plasma volume from the mean normal by 26 and 35% respectively. When the plasma volume of morbus caeruleus is compared with that of polycythemia, it will be noted that the latter shows a definite increase even over the normal.

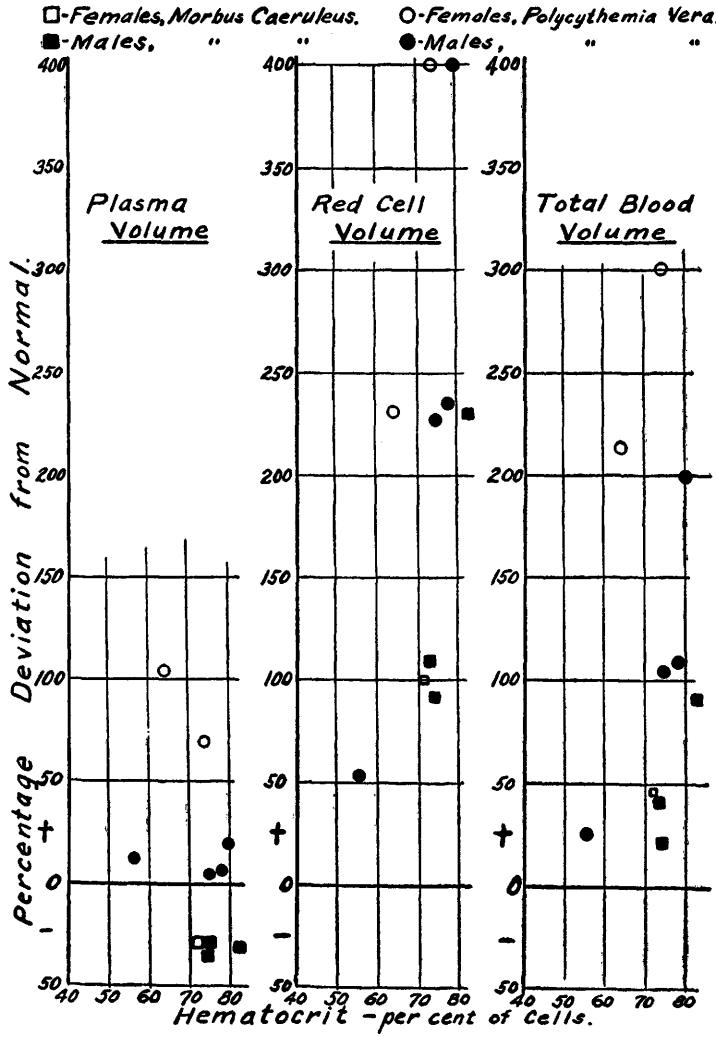
When the circulating red cell volume of morbus caeruleus is compared with the normal and with that in polycythemia vera (Table II) it is noted that for both males and females the red cell volume is decidedly increased in morbus caeruleus and strikingly increased in polycythemia vera.

The total blood volume is but moderately increased in morbus caeruleus while in polycythemia vera it is greatly increased. In one instance the increase was 300% (Fig. 1). This patient had a total blood volume of 18.28 liters of blood, approximately 3 times greater than normal.

In Fig. 1 it is noted that the plasma volumes of morbus caeruleus are all subnormal, a percentage deviation of −36%, −25%, −41%, and −28% respectively below the mean normal.

Summary. The results of the present study indicate that the plasma volume is subnormal in adult cases of morbus caeruleus while the total circulating blood volume is moderately increased, this increase being due to a considerable increase in circulating red cell volume. From the viewpoint of the disturbed dynamics of the circulation in morbus caeruleus, these blood volume findings would appear to indicate a compensatory effort on the part of the circulation to maintain a normal blood volume at the expense of a reduced plasma volume. At the same time, this permits the increase in circulating red cell volume which is necessary to compensate in part at least for the anoxia.

Fig. I. Comparison of Blood Volume in Morbus Caeruleus to that in Polycythemia Vera.



The blood volume findings in morbus caeruleus resemble those of polycythemia vera in that in both conditions the circulating red cell volume and total volume are increased both in relative and absolute values. The only difference is associated with the plasma volume change; in morbus caeruleus it is subnormal while in polycythemia vera the plasma volume tends to be slightly above normal.*

* Studies in two of the above cases were made possible through the courtesy of Dr. O. N. Nelson of the Minneapolis General Hospital.