

CORRELATION OF VARIOUS PHYSIOLOGICAL FACTORS WITH BLOOD VOLUME IN SEVERELY ANAEMIC PREGNANT WOMEN

by

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It is a well established fact now that plasma volume rises to a great extent in pregnancy. Similarly, in the anaemic state, the rise of plasma volume has been well documented. Recently, however, there has been a suggestion of decreased plasma volume in severely anaemic subjects with haemoglobin level below 4 grams per cent. (Tasker 1959).

We recently reported significantly reduced blood volumes in pregnant anaemic women with less than 4 grams of haemoglobin (Vyas *et al* 1968). Moreover, this study group did not reveal any compensatory rise due to anaemia in plasma volume. We therefore decided to investigate the correlation of blood and plasma volumes with various physiological parameters which are normally related to circulatory volume.

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Received for publication on 1-8-68.

Material and Methods

Patients with haemoglobin levels of 4 grams or less per cent have been considered severely anaemic. Consecutive 101 cases observed as indoor patients at the Department of Obstetrics and Gynaecology, Shree Sayaji Hospital and Medical College, Baroda, have been studied. Two patients have been dropped from the report for want of complete data. Seventeen patients presented during the second trimester and eighty-four during the third. A complete picture of their clinical state, when first seen, is reported elsewhere. (Vyas *et al* 1968).

Plasma volume determinations were done by dye dilution technique using Evans blue. Total, as well as per kilogram, body weight and per square meter of body surface values of blood and plasma volumes have been calculated. However, correlation is worked out with only total values since weight and surface area both get influenced by pregnancy.

Haemoglobin was estimated by Sahli's method. Packed cell volume was derived from standard Wint-

robe's tubes, centrifuged at 3000 r.p.m. for 30 minutes. Plasma proteins were estimated by electrophoretic method.

The normal values of blood and plasma volumes in normal non-pregnant adult women are taken from a study of 35 medical students from our Institution. As a control, the values were estimated in 30 pregnant women with haemoglobin levels of 9 grams per cent and above, seen during second and third trimesters of pregnancy. All the estimations have been done personally (V.R.P.) on the same apparatus.

Results

The comparison between non-pregnant normal subjects and the pregnant non-anaemic subjects con-

forms to the data observed in other studies. Plasma volumes as compared by total ($P = 0.05$) per kilogram body weight ($P = 0.0005$) and per square meter body surface area ($P = 0.0025$) showed a marked increase in control series of pregnant women. There has been no significant difference between the total and per square meter body surface blood volume values of normal non-pregnant women and control series, but highly significant difference ($P = 0.0025$) between the same values when compared as per kilogram body weight. (Table I).

In comparison between the pregnant non-anaemic women and the study group, it was found that plasma volumes were almost similar and did not show any further rise that might

TABLE I
Blood and plasma volumes

	Range in ml.	Mean	S.D.	Remarks
1. Blood volume				
(i) Total volume	A. 2818-6067 B. 3168.9-5238.5 C. 2241.8-5625.0	4275 4035.7 3333.0	548.0 422.7 527.7	Insignificant Significant
(ii) Per Kg. body weight	A. 62.1-141.9 B. 65.6-145.8 C. 55.72-110.7	85.32 98.8 76.04	14.07 20.53 21.03	Significant Significant
(iii) per square meter body surface.	A. 2113-4223 B. 2237-4110.8 C. 1701-3461	3018 3145 2458.1	509.9 674.0 288.7	Insignificant Significant
2. Plasma volume				
(i) Total volume	A. 1716-3467 B. 2165-3405 C. 1874.9-3852.8	2474 2589.3 2724.7	114.0 228.2 482.3	Significant Significant
(ii) Per kg. body weight	A. 36.67-77.21 B. 44.1-96.2 C. 38.58-94.5	53.83 63.03 62.2	8.42 11.02 11.5	Significant Significant
(iii) per square metre surface	A. 1235-2470 B. 1610-2548.8 C. 1377-2763	1733 1970 1999.6	453 140.9 327.7	Significant Insignificant

A. — Normal non-pregnant subject.

B. — Control group.

C. — Study group.

be expected due to anaemia. The blood volume values were significantly reduced in the study group.

While correlating blood and plasma volumes in the study group with packed cell volume, plasma proteins,

period of amenorrhoea and haemoglobin concentration, the values show a wide scatter (Table II-IX). All the factors have been revealed to have poor correlation with blood and plasma volumes in severely anaemic pregnant women.

TABLE II

Relation of blood volume with packed cell volume.

Blood volume in ml.	Packed cell volume					Total
	5-10	11-15	16-20	21-25	26-30	
2500		1	2			3
2500-2750	2	3	5	1		11
2750-3000		4	12	3	1	20
3000-3250		4	8	6		18
3250-3500		4	7	2		13
3500-3750		3	10		1	14
3750-4000		5	2			7
4000-4250		1	3	1	1	6
4250-4500		1		1		2
4500-4750		2	1	1		4
5625				1		1
Total	2	28	50	16	3	99

$r = 0.08.$

TABLE III

Relation of blood volume with plasma proteins

Blood volume in ml.	Plasma protein in Gms.						Total
	4 & less	4.1-4.5	4.6-5	5.1-5.5	5.6-6	6 & more	
2500				2		1	3
2500-2750			1	6	2		9
2750-3000		1	1	4	7	4	17
3000-3250		2	2	3	8	3	18
3250-3500			1	2	3	4	10
3500-3750	1			5	1	5	12
3750-4000				3	2	2	7
4000-4250			1	2	2		5
4250-4500				1		1	2
4500-4750				2	2		4
5625			1				1
Total	1	3	7	30	27	20	88

$r = 0.01,$

TABLE IV
Relation of blood volume with period of amenorrhoea

Blood volume in ml.	Period of amenorrhoea in months					Mis.	Total
	6/and less	6	7	8	9		
2500	1	1			1		3
2500-2750	1	3	2	2	3		11
2750-3000	4		4	4	8		20
3000-3250		2	5	4	6	1	18
3250-3500			4	2	6	1	13
3500-3750	1		2	5	6		14
3750-4000		2	2	1	2		7
4000-4250				3	3		6
4250-4500				2			2
4500-4750		1			3		4
5625			1				1
Total	7	9	20	23	38	2	99

r = 0.17.

TABLE V
Relation of blood volume with haemoglobin

Blood volume in ml.	Haemoglobin in grams						Total
	1-1.5	1.6-2	2.1-2.5	2.6-3	3.1-3.5	3.6-4	
2500	1			1	1		3
2500-2750	1		4	2	1	3	11
2750-3000			3	6	8	3	20
3000-3250			4	8	3	3	18
3250-3500	1		2	3	4	3	13
3500-3750		1	2	2	6	3	14
3750-4000	1		2	4			7
4000-4250		2		1	2	1	6
4250-4500				1		1	2
4500-4750			1	2		1	4
5625			1				1
Total	4	3	19	30	25	18	99

r = 0.04.

TABLE VI
Relation of plasma with packed cell volume

Plasma volume in ml.	Packed cell volume					Total
	5-10	11-15	16-20	21-25	26-30	
1750-2000		1	2			3
2000-2250		2	5	3	1	11
2250-2500	2	5	15	7		29
2500-2750			6	2	1	9
2750-3000		8	13		1	22
3000-3250		4	5	1		10
3250-3500		5	3	1		9
3500-3750			1	1		2
3750-4000		3				3
4000-4250						0
4250-4500				1		1
Total	2	28	50	16	3	99

r = 0.16.

TABLE VII
Relation of plasma volume with plasma proteins

Plasma volume in ml.	Plasma proteins in Gms.					
	4	4.1-4.5	4.6-5	5.1-5.5	5.6-6	6.1 & more
1750—2000				2		1
2000—2250			1	5	3	1
2250—2500		1	2	8	10	5
2500—2750			1		4	3
2750—3000	1	2	1	7	3	4
3000—3250					3	5
3250—3500			1	5	2	1
3500—3750					2	
3750—4000				3		
4000—4250						
4250—4500			1			
Total	1	3	7	30	27	20

$r = 0.06.$

TABLE VIII
Relation of plasma volume with period of amenorrhoea

Plasma volume in ml.	Period of amenorrhoea in months						Total
	6/and less	6	7	8	9	Mis.	
1750—2000	1	1			1		3
2000—2250		3	2	2	4		11
2250—2500	5		8	6	9	1	29
2500—2750		1	2	3	3		9
2750—3000		1	5	5	10	1	22
3000—3250	1	1	1	3	4		10
3250—3500		1	1	3	4		9
3500—3750		1			1		2
3750—4000				1	2		3
4000—4250							0
4250—4500			1				1
Total	7	9	20	23	38		99

$r = 0.17.$

TABLE IX
Relation of plasma volume with haemoglobin

Plasma volume in ml.	Haemoglobin in grams						Total
	1-1.5	1.6-2	2.1-2.5	2.6-3	3.1-3.5	3.6-4	
1750—2000	1			1	1		3
2000—2250			2	4	1	4	11
2250—2500	1		5	8	10	5	29
2500—2750				4	3	2	9
2750—3000	1		6	4	7	4	22
3000—3250		1	3	4	2		10
3250—3500	1	2	1	2	1	2	9
3500—3750				1		1	2
3750—4000			1	2			3
4000—4250							0
4250—4500			1				1
Total	4	3	19	30	25	18	99

$r = 0.17.$

Discussion

In spite of lack of similarity in weight and stature, plasma volume has shown a very significant increase in pregnant nonanaemic subjects. This confirms specific influence of pregnancy on plasma volume. Failure of any significant increase in total blood volume in this group could be easily explained on the basis of small stature of these subjects who came from very poor income group. The normal non-pregnant women, on the other hand, belonged to the upper middle class and had a higher mean weight, height and haemoglobin. Another explanation of absence of a significant rise in blood volume in spite of increased plasma volume is the comparatively smaller red cell mass in this group.

Plasma volume in anaemic pregnant women did not show the expected rise as a result of combined influence of pregnancy and anaemia when compared with the control group. Probably any further increase in plasma volume to compensate for the red cell deficiency would have been grossly hazardous for the cardiovascular state of these patients. Absence of expected increase in plasma volume thus had a beneficial influence of reducing the increase in cardiac load. What factors would contribute to such a development is difficult to determine. A study of plasma volume in severely anaemic non-pregnant women, which has been in progress, may provide useful comparison.

Lack of correlation between plasma protein and plasma volume needs further explanation. In normal pregnancy too, various changes in plasma

proteins have been noted by Hytten and Leitch (1964). They further observe that more research is required to understand these changes. Probably the behaviour of plasma proteins in pregnancy is quite independent of plasma volume.

The queer findings in plasma volume figures and markedly diminished red cell mass have probably so influenced blood volume figures that correlation with other known parameters is lost.

A linear relationship exists between plasma volume and haemoglobin with red cell mass.

In conclusion, it may be said that in pregnancy complicated with severe anaemia, in addition to red cell volume, probably other factors have a deciding influence rather than the common physiological factors like haemoglobin, packed cell volume, period of amenorrhoea and plasma proteins. It may be that poor nutrition may have been responsible.

Summary

Blood and plasma volume figures in normal non-pregnant, pregnant non-anaemic and severely anaemic pregnant women are presented. Statistically insignificant relationship is reported with the physiological parameters known to influence blood volume in the last group.

Acknowledgements

We are grateful to Dr. P. T. Acharya, Assistant Professor of Biochemistry, for allowing us laboratory facilities. Unichem (India) kindly supplied the dye for the study. Dr. Hytten, Medical Research Unit, Uni-

versity of Newcastle-upon-Tyne, took keen interest in the work and we acknowledge with sincere gratitude his guidance in the presentations of this material. We are also thankful to the Dean, Medical College, Baroda, for allowing us to publish this data.

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