

# BLOOD VOLUME IN TOXAEMIAS OF PREGNANCY

by

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Needless to emphasize the role of estimation of blood volume in toxæmias of pregnancy. Conflicting reports have appeared in literature with regard to the changes in blood volume during pregnancy (Ian Cope, 1958; and Lund *et al.*, 1958). Very few investigations with regard to blood volume have been carried out on cases of eclampsia. Keeping this fact in view these investigations were undertaken.

## Material and Methods

Twenty-five cases of toxæmia were studied. Two estimations were made of all the values at variable intervals to note any change, after treatment, in these cases of pre-eclampsia and eclampsia. The criteria adopted for selection of the cases were:

- (a) Blood pressure above 140/90 mm. Hg.
- (b) Albuminuria of variable degree.
- (c) Oedema of varying severity.

These cases were divided into two grades:

### Grade I (mild toxæmia)

These were the cases who had:

- (a) Blood pressure below 160/100 mm. Hg.

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- (b) Albuminuria from a trace to 0.2 gm. per litre.
- (c) Slight oedema over the feet.

### Grade II (Severe toxæmia)

These were the cases who had:

- (a) Blood pressure above 160/100 mm. Hg.
- (b) Massive albuminuria.
- (c) Gross oedema.

### Eclampsia

These cases had convulsions in addition to the above signs of toxæmia.

First estimation was done as soon as possible after admission when patient was sufficiently sedated for the estimation to be carried out. Second estimation was done at a variable period after the first one depending on the case. No case of post-partum eclampsia was taken, to avoid any errors in plasma and blood volume due to normal physiological changes occurring after delivery. For the same reason both the estimations were done before delivery of the child. In one case the second determination of blood volume could not be assayed because of the death of the patient soon after the first estimation. Effort was made to take the weight in as many patients as possible to calculate surface area; but in some it was not possible because of the patient lying comatose during the time of the test.

Blood volume was estimated according to the technique described by Chinard *et al.* (1956).

#### Observations

**Pre-eclampsia group:** Nine pregnant women with pre-eclampsia, between 22-23 years were studied. They were between 28 and 36 weeks of gestation. Their height varied from 4 feet 11 inches to 5 feet 3 inches. Their weights ranged between 100 to 164 pounds. The following results were obtained:

deviation of  $\pm 394$  ml. and standard error of the mean being  $\pm 141$  ml.

4. The total blood volume (B.V.) varied between 2783 ml. and 5722 ml., the mean value for total blood volume was 4478 ml. with a standard deviation of  $\pm 1049$  ml. and a standard error of the mean being  $\pm 314$  ml.

5. The blood volume per kilogram body weight (B.V. ml./Kg.) ranged between 62 ml. to 104 ml., the mean was 77.4 ml. with a standard deviation of  $\pm 15.5$  ml. and a standard error being  $\pm 5.5$  ml.

TABLE 1

No. of observations (9)	P.V. ml	P.V. ml/kg	P.V. ml/sq. m.	B.V. ml	B.V. ml/kg.	B.V. ml/sq.m.	Haema-tocrit %	Haemo-globin gm. %
Range	1948 to 4020	43.0 to 73.0	1401 to 2544	2783 to 5722	62.0 to 104.00	2003 to 3661	31.0 to 41.2	10.0 to 14.0
Mean	3045	53.0	1959	4478	77.4	2873	36.0	11.4
S. D. $\pm$	693	10.3	394	1049	15.5	605	3.7	1.4
S. E. $\pm$	248	3.7	141	314	5.5	216	1.3	0.5

1. The total plasma volume (P.V.) ranged between 1948 ml. to 4020 ml. The mean value was 3045 ml. with a standard deviation (S.D.) of  $\pm 693$  ml. and standard error of the mean (S.E.) being  $\pm 248$  ml.

2. The plasma volume per kilogram body weight (P.V. ml./Kg.) varied between 43 ml. to 73 ml., the mean value was 53 ml. with a standard deviation of  $\pm 10.3$  ml. and standard error of the mean being  $\pm 3.7$  ml.

3. The plasma volume per square meter of body surface (P.V. ml/sq. meter) area ranged between 1401 ml. to 2544 ml., the mean value for the same was 1959 ml. with a standard

6. The blood volume per square meter body surface area (B.V. ml./sq.m.) varied between 2003 ml. to 3661 ml.; the mean being 2873 ml. having standard deviation and standard error of  $\pm 605$  ml. and  $\pm 216$  ml. respectively.

7. The haematocrit level varied between 31.0% to 41.2% having a mean value of 36% with a standard deviation of  $\pm 3.7$  and standard error  $\pm 1.3$ .

8. The haemoglobin level ranged between 10 gm% to 14 gm% with a mean of 11.4 gm% and a standard deviation and standard error of

$\pm 1.49$  gm. and  $\pm 0.5$  gm., respectively.

### Eclampsia Group

Sixteen cases of eclampsia who had fits either at the time of admission, or before that, were investigated. They were of the ages between 18 years and 40 years. Their heights varied between 4 feet 11 inches and 5 feet and 5 inches. Their weights ranged between 110 pounds and 152 pounds.

In three, out of these sixteen cases, weight could not be recorded as patients were comatose during the period of investigation (These three cases have been excluded from the statistical analysis). As stated earlier, for each patient two estimations were done at variable intervals. The following results were obtained:

deviation and standard error of  $\pm 11.6$  and  $\pm 3.3$ , respectively.

3. The plasma volume per square meter of the body surface area ranged between 1038 ml. and 2544 ml. The mean of the same was 1461 ml. with a standard deviation and standard error of  $\pm 417.4$  ml. and  $\pm 119$  ml., respectively.

4. The total blood volume varied between 2647 ml. and 5786 ml., the mean being 3844 ml. having a standard deviation of  $\pm 782$  ml. and standard error of  $\pm 233$  ml.

5. The blood volume per kilogram body weight ranged between 42.5 ml. to 115 ml., the mean was 66.7 ml., with a standard deviation and standard error of  $\pm 17.8$  ml., and  $\pm 5.0$  ml., respectively.

6. Calculated on the surface area

TABLE II

No. of observations (13)	Total P.V. ml	P.V. ml/kg	P.V. ml/sq.m.	Total B.V. ml	B.V. ml/kg	B.V. ml/sq.m.	Haematocrit %	Haemoglobin gm. %
Range	1641 to 3750	26.4 to 73.0	1038 to 2544	2647 to 5786	42.5 to 115.0	1675 to 4018	33.3 to 47.6	8.5 to 18.0
Mean	2484	42.6	1461	3844	66.7	2437	41.1	13.3
S. D. $\pm$	648	11.6	417.4	782	17.8	643	4.3	2.8
S. E. $\pm$	185	3.3	119	223	5.0	184	1.2	0.43

1. The total plasma volume ranged between 1641 ml. to 3750 ml., the mean value for total plasma volume was 2484 ml. with a standard deviation of  $\pm 648$  ml. and a standard error of the mean  $\pm 185$  ml.

2. The plasma volume per kilogram body weight varied between 26.4 ml. to 73 ml. the mean value for the same was 42.6 ml. with a standard

basis, the blood volume per square meter varied between 1675 ml. and 4018 ml., the mean for the same was 2437 ml. with a standard deviation of  $\pm 643$  ml. and a standard error of  $\pm 184$  ml.

7. The haematocrit level ranged between 33.3% to 47.6% with a mean value 41.1% with a standard deviation of  $\pm 4.3$  and a standard error of

the mean being  $\pm 1.2$ .

8. The haemoglobin level was in the range of 8.5 gm% to 18 gm%, the mean value being 13.3 gm%, having a standard deviation and standard error of the mean  $\pm 2.8$  and  $\pm 0.43$  gm., respectively.

#### Discussion and Results

White (1950) found in her studies that the pattern of changes in blood volume in patients of essential hypertension without pre-eclampsia was similar to that of normal patient. Very few observations have been made on the changes in plasma and blood volume in patients with pre-eclampsia. Dieckmann (1952) stated that in patients with mild pre-eclampsia, the changes in blood volume were similar to those found in normal pregnancy. In severe pre-eclampsia and eclampsia, both plasma volume and blood volume were decreased. Ian Cope (1961) reported results on 8 patients who had pre-eclampsia and observed that changes in mild pre-eclampsia were similar to those in normal pregnancy. Average plasma volume was

43.3 ml./kg. which was little lower than that of normal pregnancy (47 ml./kg.). Friedberg (1958) found that average plasma volume of toxæmic patients was lower than that of normal patients. Freis and Kanny (1948) also reported lower plasma volume in pre-eclampsia and eclampsia.

In the present series the fall in plasma and blood volume was noted in severe pre-eclampsia which became all the more aggravated with the onset of eclampsia. Further high values in haemoglobin and haematocrit were also noted in both the series. With improvement in general condition of the patients, the plasma volume and blood volume increased with corresponding changes in haematocrit and haemoglobin. With the deterioration in general condition, these values decreased. It can be stated that the absolute values obtained in severe cases were definitely lower than those obtained in less severe cases. Thus there may be some correlation between the severity of symptoms and haemoconcentration.

TABLE III  
Plasma Volume *Ml./Kg. Body Weight*

Group	No. of observations	Mean (M)	Standard deviation	Standard error of the mean (e)	T $\frac{M_1 - M_2}{\sqrt{\frac{e_1^2}{e_1^2} + \frac{e_2^2}{e_2^2}}}$
Normal pregnant women	29	70.0	12.4	2.3	4
Pre-eclampsia group	9	53.0	10.3	3.7	2
Eclampsia group	16	42.6	11.6	3.4	6.8

TABLE IV  
*Plasma Volume Ml/Sq Meter Body Surface Area*

Group	No. of observations	Mean (M)	Standard deviation	Standard error of the mean (e)	T
Normal pregnant women	29	2528	436	82.2	3.4
Pre-eclampsia group	9	1959	394	141	2.7
Eclampsia group	16	1461	417	119	7.4

TABLE V  
*Blood Volume/Kg. Body Weight*

Group	No. of observations	Mean (M)	Standard deviation	Standard error of the mean (e)	T
Normal pregnant women	29	98.0	16.8	3.1	3.5
Pre-eclampsia group	9	77.4	15.5	5.5	1.4
Eclampsia group	16	66.7	17.8	5.0	5.3

TABLE VI  
*Blood Volume Ml/Sq Meter Body Surface Area*

Group	No. of observations	Mean (M)	Standard deviation	Standard error of the mean (e)	T
Normal pregnant women	29	3561	597	113	2.8
Pre-eclampsia group	9	2873	605	216	1.5
Eclampsia group	16	2473	643	184	5

### Conclusions

The present study with regard to investigation of blood volume on the pre-eclamptic and eclamptic patients reveals the following facts:

1. There is a decrease in plasma volume as compared to the normal pregnant women — the decrease being 20.6% and 35.2% in pre-eclamptic and eclamptic group respectively.

2. There is a decrease in blood volume as compared to the normal pregnant women — the decrease being 17.2% and 29% in pre-eclampsia and eclampsia patients, respectively.

3. There is a definite significant decrease in plasma volume as compared to normal pregnant women in both the groups, the value of T being 4 for pre-eclampsia patients and 6.8 for eclampsia group. These results also hold good for plasma volume/sq. meter body surface area. However, there is doubtful difference between pre-eclampsia and eclampsia groups (Table III and IV).

4. There is a definite significant decrease in blood volume between normal pregnant women, pre-eclampsia and eclampsia groups with values of T being 3.5 and 5.3, respectively. There is no significant difference between pre-eclampsia and eclampsia groups as the value of T is 1.4. The same holds good for blood volume per sq. meter body surface area.

5. There is no statistical difference in haemoglobin percentage between the normal pregnant women and pre-eclampsia group as the value of T is

1.6. However, when the values of normal pregnant women and eclampsia groups are compared there is a significant increase as the value of T is 3.4, but when the pre-eclampsia and eclampsia groups are compared the value of T does not indicate a statistical difference.

6. There is very little difference between the normal pregnant women and pre-eclampsia groups, the value of T being 2.6. Definitely there is a significant increase in haemoconcentration when the normal pregnant women values are compared to eclampsia group. There is also a statistical significant difference between the pre-eclampsia and eclampsia group as the value of T is 3.

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