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Plasma volumes in a group of healthy Malaysians

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BLOOD VOLUME STUDIES have reached a state where they are no longer restricted to academic physiology. Its importance is now well established. As a monitoring device, accurate measurements of circulating blood volume have often meant the difference between success and failure, in the management of the problem patient (Behling *et al.,* 1952). The indications for blood volume measurements are numerous and encompass all medical specialities (3, 10, 11, 13, 15)

The importance of blood volume measurements in surgery has been shown by the reduction of 50 percent in mortality in the geriatric patient (Albert S.N., 1971) and the low morbidity when patients were monitored with pre and post operative blood volume estimations (6, 12, 14, 16). In infants and children, any blood loss, although minute in terms of size and weight of the patients may well be excessive, in proportion to their circulating volume (Davenport *et al.,* 1963).

Before such estimation can have clinical use, it is mandatory to have a reasonable estimate of the mean volume of normal individuals in a country. Such a data is not available in this country. Hence this study was undertaken to obtain this basic data among healthy normal male Malaysian medical students.

Material

Ten disease free male medical students between the ages of 20 and 25 years volunteered for the measurement. Their height and weight were recorded and surface area calculated. ^{125}I-albumin, a weak and pure gamma emitting isotope was used as the tracer material (27.3 and 35.4 ke V, half-life, 60 days). ^{125}I HSA (iodinated human serum albumin) takes about 10 – 15 minutes for equilibration in the blood stream when injected and the rate of loss of activity during this period is almost negligible. The radio iodinated albumin used for this study was obtained from the Radiochemical Center, Amersham, England (Lot 201AA).

Method

Plasma volume was measured by the in-vivo dilution method. Approximately 5 microcuries (5 uCi) of an aqueous solution of labelled albumin was prepared and a known volume was injected as a bolus intravenously from a calibrated syringe. Care was taken to check that the tip of the needle was completely inserted within the vein throughout the period of injection. 5 ml blood samples were taken in pre-heparinised syringes without stasis after 15, 30 and 45 minutes of injection from a distant vein away from the site into which the labelled albumin was injected so as to exclude contamination from the injection area.

Hematocrit estimation by the microcapillary method was done on all blood samples. The blood was then centrifuged to separate the plasma. A standard of known dilution was also prepared from the same aqueous solution and the percentage of free iodine was determined. Radioactivity in duplicate aliquots of the diluted standard (corrected for free iodine) and the plasma sample was measured in a gamma scintillation counter adjusted for maximum efficiency for the measurement of ^{125}I.

The plasma radioactivity observed, expressed as a linear function on a semilogrithmic paper against time was extrapolated to zero time. The slope of the graph indicated a rate of disappearance of activity between 6 to 10 percent/hour. With this procedure the theoretical radioactivity which would have been achieved had mixing taken place instantaneously and without loss of the tracer from the intravascular space could be obtained. All counting rates were corrected for background count.

The plasma volume (PV) was calculated as follows:

$$PV = \frac{VDn_s}{n_0}$$

where V = volume of labelled albumin injected
D = dilution factor of the standard (100)
n_s = the counting rate of the standard
n_0 = the counting rate of the plasma at 0 time

Total blood volume was calculated using the formula,

$$\text{Total blood volume} = \frac{\text{Plasma volume}}{1 - \text{Hematocrit}}$$

Total blood volume and red cell volumes were calculated after correction had been made for trapped plasma and for differences between large vessels hematocrit (LVH) and whole body hematocrit (WBH).

Table 2

Plasma Volumes Measured With ^{125}I-albumin
(Mean ± S.E.M.)

Present Study	Tarazi et al 1969	Ibsen & Leth 1973
10 subjects	11 subjects	18 subjects
1526±17.8 ml/M^2	1562±38 ml/M^2	1891±44 ml/M^2

Discussion

From the data presented, it can be seen that plasma volume measured by this method and corrected for surface area gave a reproducible result (S.E.M. ± 17.8%), the greatest deviation from the mean being 99 c.c/M^2. The results were lower than those reported by Tarazi *et al.* (1976) but the technique employed differed slightly although the tracer material was the same.

Total blood volume (TBV) and red cell volume (RCV) were only estimates as they depended on how truly the hematocrit reflected the red cell distribution. The results showed a standard error of mean of ±45.3 for TBV, the greatest deviation from the mean being 250 c.c/M^2 and ±32.5 for RCV, the greatest deviation being 188 c.c/M^2. It seemed that the error was greater for the calculated values.

Table I

Plasma volume and estimated total blood volume and red cell volume of healthy Malaysian males age 20 – 25 years of average height 166 cm and weight 57.13 kg.

Student	BSA	Plasma Vol.		WBH	Total Blood Vol.		Red Cell Vol.	
no.	sq M	ml	ml/M^2	%	ml	ml/M^2	ml	ml/M^2
1.	1.78	2784	1564	38.9	4556	2560	1772	996
2.	1.58	2486	1573	42.6	4331	2741	1845	1168
3.	1.68	2504	1490	40.9	4237	2522	1733	1032
4.	1.55	2430	1568	43.5	4301	2775	1871	1207
5.	1.61	2386	1482	43.8	4245	2637	1859	1155
6.	1.52	2413	1588	45.5	4428	2913	2015	1326
7.	1.65	2355	1427	43.0	4132	2504	1777	1077
8.	1.74	2666	1532	43.0	4677	2688	2011	1156
9.	1.57	2469	1573	43.8	2393	2798	1924	1225
10.	1.62	2370	1463	41.4	4044	2496	1674	1033
Average ± S.E.M.		2486 ± 43.6	1526 ± 17.8	42.6	4334	2663 ± 45.3	1848	1138 ± 32.5

The fundamental usefulness of blood volume determinations lies in situations where measurements of hematocrit or hemoglobin levels do not necessarily reflect the level of red cell or plasma volume, as for example, after the loss of whole blood by hemorrhage or the loss of both plasma and red cells at different rates in patients with burns. The hematocrit and hemoglobin estimations in such cases only denote the concentration and not volume. Hence, component replacement of deficits in blood volume can only be achieved by its actual measurement.

The ^{125}I-albumin used in this study causes less irradiation of tissues and its energy can be easily discriminated from higher energy emitting isotopes. Therefore, this can also be used for simultaneous measurement of both components of blood – ^{125}I HSA for plasma volume and ^{51}Cr labelled cells for red cells volume. Simultaneous measurement of plasma and red cell volumes (Grable *et al.*, 1968) give greater accuracy in blood volume but for routine measurements in clinical practice and for the sake of convenience, one tracer is commonly used and the other compartment calculated.

On the average, the dilution volume measured with protein-bound tracers overestimates blood volume by approximately 10 percent because the volume measured with these tracers comprises both the plasma volume and an undetermined portion of the extravascular space.

Plasma volumes measured by using radioactive iodine tagged albumin have compared favourably with those found with T1824 (Crispell *et al.*, 1950) and without the disadvantage of tissue discolorations and colorimetric problems.

Conclusion

A simple technique of plasma volume measurement had been employed in this study. The results obtained are comparable to other series. It is believed that the results presented for the average Malaysian males have not been recorded before. These data should now offer a firm basis for the usefulness of blood volume measurement in the management of medical and surgical problems in this country.

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