THE EFFECT OF SIGNIFICANT WEIGHT CHANGE ON THE PREDICTED PLASMA VOLUME

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With the introduction of improved dye methods for determining the plasma volume, numerous clinical studies have been made in various conditions. It has been found that the plasma volume is influenced by age, sex, height, weight, muscularity (1), position, exercise (2 to 5), seasonal and climatic factors (6), as well as by different disease states.

Gibson and Evans concluded that normal values are best estimated from surface area measurements if no marked disturbance in weight-to-height relationship exists, and from height in those cases presenting weight changes due to disease (1). Repeated observations have shown that the plasma volume usually approximates 1600 ml. per square meter of body surface area. It has also been suggested that for practical estimation, the plasma volume may be calculated from body weight, using the value of 45 ml. per kgm. (7).

The present study was undertaken because of the marked discrepancies noted on occasion between actual and estimated plasma volume measurements, based on surface area, raising the question as to the effect of significant weight change on the predicted values.

MATERIALS AND METHODS

Five underweight and five obese patients were studied either on the wards of the Presbyterian Hospital or in the Vanderbilt Clinic. In addition, three patients were studied before and after significant weight change. One (M. H.) was a hospital patient with uncomplicated and afebrile active pulmonary tuberculosis at the right lung apex, who gained seven kgm. in weight on a high caloric diet. The second (E. S.) was an obese ambulatory patient with mild but asymptomatic hypertension, no signs of cardiac insufficiency, who lost eighteen kgm. on a 1200 calorie diet without fluid or salt restriction. The third patient (C. G.) lost twenty-eight kgm. in association with widespread metastatic carcinoma of the prostate.

Patients having acute infection, cardiac insufficiency, renal disease, liver disease, hypoalbuminemia, endocrine or metabolic disorders, anemia, dehydration or fever were not included in this report.

Blood samples for hematocrit, serum protein and volume measurements were obtained with the patient lying flat after at least a twenty-minute period of inactivity in that position. The plasma volume was determined with the blue dye T.1824, the optical density being measured with the photoelectric colorimeter (8), using a serum sample drawn ten minutes after the injection of the dye (7). Predicted plasma volume values based on surface area were arbitrarily calculated on the basis of 1600 kgm. per square meter, while predictions based on height were determined from the data of Gibson and Evans (1). The difference between observed and predicted values was expressed as a percentage deviation.

RESULTS

Based on surface area, the plasma volume in five underweight patients (Table I) was invariably higher than predicted, the deviation being ten

TABLE I

Comparison of estimated and predicted plasma volume determinations in five underweight patients

Case	Sex	Height	Weight	Surface area	Hemato-crit	Plasma volume	Predicted plasma volume		Deviation from predicted plasma volume	
							Based on surface area	Based on height	Based on surface area	Based on height
		cm.	*kgm.*	*sq. m.*	*per cent cells*	*ml.*	*ml.*	*ml.*	*per cent*	*per cent*
1	F	141	46	1.32	39	2320	2112		+10	*
2	F	163	46	1.47	38	2480	2352	2504	+5	−2
3	M	174	63	1.76	44	3520	2816	3090	+25	+14
4	M	150	52	1.46	40	3000	2336		+29	*
5	M	159	44	1.42	42	2660	2272	2550	+17	+4

* Data insufficient for volume prediction on such short patients.

TABLE II

Comparison of estimated and predicted plasma volume determinations in five obese patients

Case	Sex	Height	Weight	Surface area	Hemato-crit	Plasma volume	Predicted plasma volume		Deviation from predicted plasma volume	
							Based on surface area	Based on height	Based on surface area	Based on height
		cm.	*kgm.*	*sq. m.*	*per cent cells*	*ml.*	*ml.*	*ml.*	*per cent*	*per cent*
1	M	173	78	1.92	45	3020	3072	2986	−2	+1
2	F	158	81	1.83	42	2080	2928	2250	−29	−7
3	F	165	72	1.79	40	2360	2864	2436	−18	−3
4	M	179	90	2.09	46	3060	3344	3067	−8	0
5	F	169	69	1.79	41	2500	2864	2430	−13	+3

per cent or greater in all but one. In five obese patients (Table II) the reverse was true, all showing somewhat smaller volumes than predicted, three with more than a ten per cent deviation. On the basis of height alone, the percentage deviation of determined volume from predicted volume was not significant.

With reference to the three patients studied before and after change in weight (Table III), the one with seven kgm. weight gain (M.H.) exhibited a decrease in plasma volume, despite a six per cent rise in surface area and predicted values. The other two (E.S. and C.G.) showed practically no change in plasma volume after an eighteen and a twenty-eight kgm. weight loss respectively, although the surface area and hence the predicted volume measurement decreased by ten per cent in one and by twenty-one per cent in the other. No significant changes in hydration, serum protein or red blood cell concentration took place during the period of observation.

DISCUSSION

It has already been pointed out that muscular persons may have relatively more and obese individuals less blood per unit of body weight than those of normal habitus (1). Gibson and Evans suggest that the varying proportions of blood in such tissues as muscle and fat may account for this difference.

The evidence presented in this paper confirms the fact that marked deviations from normal in weight, and therefore in surface area, do not always cause a parallel fluctuation in plasma volume. Not only do thin and obese persons tend to have a plasma volume more closely approximating that of persons of average weight, but significant changes in weight in individual cases are not accompanied by proportionate changes in the plasma volume. In situations associated with marked disturbance in weight to height relationship, as pointed out by Gibson and Evans, predicted values

TABLE III

Comparison of estimated and predicted plasma volume determinations in three patients before and after significant change in body weight

Patient	Sex	Age	Date	Height	Weight	Sur-face area	Hema-tocrit	Hemo-globin	Serum proteins	Plasma volume	Predicted plasma vol. based on surface area	Change in plasma volume	Change in predicted plasma volume
				cm.	*kgm.*	*sq. m.*	*per cent cells*	*grams per 100 ml.*	*grams per 100 ml.*	*ml.*	*ml.*	*per cent*	*per cent*
M.H.	F	27	8-13-45	160	43	1.41	41	12.8	6.1	2540	2256		
			10-24-45	160	50	1.50	43	14.2	6.4	2360	2400	−7	+6
E.S.	F	52	8-10-45	164	82	1.89	45	13.6	7.2	2720	3024		
			10-19-45	164	64	1.70	44	14.0	6.9	2680	2720	−1.5	−10
C.G.	M	62	6-8-45	175	78	1.94	47	12.2	6.1	2940	3104		
			1-4-46	175	50	1.60	44	11.6	5.8	3100	2560	+5	−21

based on height appear to afford the most useful estimate of normal.

It is therefore apparent that clinical studies of the plasma volume may be in error if the underlying disorder is preceded or accompanied by any marked degree of weight loss or emaciation and if weight or surface area are employed in predicting the normal. Similarly, studies of alterations in the plasma volume in given disorders may lead to erroneous conclusions if the patients involved are either abnormally thin or obese unless some other basis of comparison than weight is used.

The range of variation encountered in normals (1), coupled with the many constitutional and environmental factors known to influence the plasma volume, combine to make predicted volume measurements rough approximations at best. In the presence of significant weight change in either direction, it is suggested that height or ideal weight figures be used in the calculation, taking into consideration the habitus of the patient.

CONCLUSIONS

1. Plasma volume determinations in five underweight patients were found to be higher than predicted values based on surface area, whereas in five obese individuals the reverse was true; much closer approximation was obtained when height was used in the prediction of normal values.

2. Weight loss and weight gain in three patients studied were not accompanied by proportionate changes in plasma volume.

3. In the presence of significant weight loss or obesity, it is suggested that height or ideal weight be employed to predict the normal plasma volume.

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