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, muscu-
larity (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 rela-
tionship 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 sug-
gested 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 be-
tween actual and estimated plasma volume meas-
urements, based on surface area, raising the ques-
tion 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 pa-
tient 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 vol-
ume 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 ex-
pressed 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>
<thead>
<tr>
<th>Case</th>
<th>Sex</th>
<th>Height</th>
<th>Weight</th>
<th>Surface area</th>
<th>Hematocrit</th>
<th>Plasma volume</th>
<th>Predicted plasma volume</th>
<th>Deviation from predicted plasma volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>cm.</td>
<td>kgm.</td>
<td>sq. m.</td>
<td>per cent</td>
<td>ml.</td>
<td>ml.</td>
<td>ml.</td>
</tr>
<tr>
<td>1</td>
<td>F</td>
<td>141</td>
<td>46</td>
<td>1.32</td>
<td>39</td>
<td>2320</td>
<td>2112</td>
<td>208</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>163</td>
<td>46</td>
<td>1.47</td>
<td>38</td>
<td>2480</td>
<td>2352</td>
<td>126</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>174</td>
<td>63</td>
<td>1.76</td>
<td>44</td>
<td>3520</td>
<td>2816</td>
<td>705</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>150</td>
<td>52</td>
<td>1.46</td>
<td>40</td>
<td>3000</td>
<td>2336</td>
<td>664</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>159</td>
<td>44</td>
<td>1.42</td>
<td>42</td>
<td>2660</td>
<td>2272</td>
<td>388</td>
</tr>
</tbody>
</table>

* Data insufficient for volume prediction on such short patients.
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.

**TABLE II**

<table>
<thead>
<tr>
<th>Case</th>
<th>Sex</th>
<th>Height</th>
<th>Weight</th>
<th>Surface area</th>
<th>Hematocrit</th>
<th>Plasma volume</th>
<th>Predicted plasma volume</th>
<th>Deviation from predicted plasma volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>cm.</td>
<td>kgm.</td>
<td>sq. m.</td>
<td>per cent</td>
<td>ml.</td>
<td>ml.</td>
<td>per cent per cent</td>
</tr>
<tr>
<td>1</td>
<td>M</td>
<td>173</td>
<td>78</td>
<td>1.92</td>
<td>45</td>
<td>3020</td>
<td>3072</td>
<td>-2 +1</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>158</td>
<td>81</td>
<td>1.83</td>
<td>42</td>
<td>2200</td>
<td>2298</td>
<td>-29 -7</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>165</td>
<td>72</td>
<td>1.79</td>
<td>40</td>
<td>2500</td>
<td>2864</td>
<td>-18 -3</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>179</td>
<td>90</td>
<td>2.09</td>
<td>46</td>
<td>3000</td>
<td>3344</td>
<td>-8 0</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>169</td>
<td>69</td>
<td>1.79</td>
<td>41</td>
<td>2500</td>
<td>2864</td>
<td>-13 +3</td>
</tr>
</tbody>
</table>

**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**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Age</th>
<th>Date</th>
<th>Height</th>
<th>Weight</th>
<th>Surface area</th>
<th>Hematocrit</th>
<th>Hemoglobin</th>
<th>Serum proteins</th>
<th>Plasma volume</th>
<th>Predicted plasma vol. based on surface area</th>
<th>Change in plasma volume</th>
<th>Change in predicted plasma volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.H.</td>
<td>F</td>
<td>27</td>
<td>8-13-45 10-24-45</td>
<td>160</td>
<td>50</td>
<td>1.50</td>
<td>41</td>
<td>12.8</td>
<td>6.1</td>
<td>2540</td>
<td>2256</td>
<td>-7</td>
<td>+6</td>
</tr>
<tr>
<td>E.S.</td>
<td>F</td>
<td>52</td>
<td>8-10-45 10-19-45</td>
<td>164</td>
<td>64</td>
<td>1.70</td>
<td>44</td>
<td>14.0</td>
<td>6.9</td>
<td>2720</td>
<td>2680</td>
<td>-1.5</td>
<td>-10</td>
</tr>
<tr>
<td>C.G.</td>
<td>M</td>
<td>62</td>
<td>6-8-45 1-4-46</td>
<td>175</td>
<td>50</td>
<td>1.60</td>
<td>44</td>
<td>11.6</td>
<td>5.8</td>
<td>2940</td>
<td>3100</td>
<td>+5</td>
<td>-21</td>
</tr>
</tbody>
</table>
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.

BIBLIOGRAPHY


