BLOOD VOLUME: A COMPARATIVE STUDY*

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IN ANAESTHESIA more than in any other field, a knowledge of the adequacy or otherwise of a patient's blood volume is of prime importance. The stability of the vascular portion of the cardiovascular system depends primarily on three factors, namely vasomotor tone, gravity, and blood volume in relation to blood vessel capacity. During anaesthesia, provided the myocardium is intact and unaffected by drugs, the major causes of hypotension are directly related to the effects which the anaesthetic agents exert on the vascular system. Frequently this is a depression of sympathetic vasomotor tone. If the initial blood volume has been deficient and motor tone then is reduced by interference with vasomotor reflexes leading to an increase in the capacity of the vascular bed, a potentially serious situation may well develop. This will be aggravated if extreme changes in position make the blood gravitate towards the periphery. Under these circumstances a blood volume deficit in the order of 10 to 15 per cent is tolerated poorly.

In this presentation an attempt is made to assess the relative values of various means of determining adequacy of blood volume and a comparative study of these methods is being reported.

METHODS OF DETERMINING BLOOD VOLUME

Past experience has shown that clinical evaluation alone is an unreliable method of assessing blood volume when this is based on a clinical history of weight loss, limited food or fluid intake, or such physical findings as a dry, parched tongue or dryness of skin with poor tissue turgor, etc.

Weight loss

The relation between weight loss and blood volume is quite controversial. Henegar¹ states that patients with weight loss have a larger than normal blood volume on the basis of their present weight. Wiederanders *et al.*² on the other hand compared red cell volume and haematocrit in patients with weight loss and found that haematocrit readings suggested less severe anaemia than is apparent from the actual values of red cell volume. However, they found very little correlation between the degree of weight loss and the haematocrit or total red cell volume. They concluded that the present body weight was the proper value to consider in determining the adequacy of blood volume.

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Haemoglobin and haematocrit

Many clinicians have relied entirely on haemoglobin and haematocrit readings for blood volume assessment. Haemoglobin and haematocrit readings however really only denote concentration and do not express quantity as such. The haematocrit may be normal both in acute and chronic hypovolaemia when vasoconstriction is present. It may be found to drop significantly after vasodilatation when haemodilution takes place. On the other hand, Boyan³ and other workers feel that if blood volume and haematocrit have been determined simultaneously once, serial haematocrits thereafter provide a satisfactory guide for fluid replacement. Wiederanders *et al.*² prefer total red cell volume to haematocrit as a guide for blood replacement. However, through the work of Shires *et al.*,⁴ confirmed by Boyan,³ it is known that the so-called "third space" can sequester large amounts of fluids during operation which are unavailable for maintaining an adequate circulating blood volume. Boyan states that haematocrit readings below 30 indicate the use of whole blood whereas a haematocrit of 45 and above indicates straight fluid administration. Values between 30 and 45 must be taken in conjunction with baseline values and clinical signs before a decision can be reached as to the type of volume replacement needed. However, if only haemoglobin and haematocrit are taken into consideration one may be misled since both might be low in the presence of a normal red blood cell mass when there is excess plasma dilution.

Central venous pressure

Central venous pressure as a guide to volume replacement has had many proponents within the past few years. McLean of Montreal and Lillehei of Minnesota have emphasized the need of administering sufficient volumes to raise the central venous pressure to normal or even to above-normal levels. Friedman *et al.*⁵ in comparing central venous pressure and direct serial volume measurements as guides to replacement therapy, studied eighty patients and found large deficits in blood volume which were not reflected in an altered central venous pressure. They concluded that the current practice of administering blood to bring the central venous pressure to normal or above normal could easily lead to overload. Ryan *et al.*⁶ studied one hundred patients who had preoperative central venous pressures in the range of 0.5 to 14 cm. H₂O with an average of 6 cm. H₂O. They found very little correlation between central venous pressure and changes in blood volume, and thought that a reduction in the haematocrit actually followed blood loss more closely than did central venous pressure.

Chlorpromazine test

Winnie and Collins,⁷ reporting on the use of chlorpromazine (Largactil®) in shock, advocate a test dose of 0.2 mg./kg. chlorpromazine intravenously after blood replacement is judged adequate by clinical criteria, in order to ascertain whether there is or is not a residual deficit. If a drop in blood pressure occurs, the degree of this hypotension is believed to be related to the degree of residual blood volume deficiency. The claim to validity of this test is based on the peripheral alpha-blocking properties of chlorpromazine. In reality, several other

effects of the agent enter into the picture. Listed in order from central to peripheral mechanisms, these are: (1) depression of vasomotor reflexes, mediated by hypothalamus or brain-stem; (2) depression of the vasopressor carotid sinus reflex; (3) direct myocardial depression. In addition, this drug has a multitude of other actions affecting almost all systems of the body. In summary, it is felt that every facet of the action of chlorpromazine should be taken into consideration when evaluating effects of its intravenous administration.

Radioactive methods

Many radioactive tracers are available today and some of them such as CR⁵¹, radioactive iron, radioactive phosphorus, or K⁴² could be used, although each of them has its own disadvantages. Radioactive iodinated human serum albumin (RIHSA®), using I¹³¹, has the most general applicability and has been used in this study employing the Volemetron developed by Williams and Fine.⁸ Compared with the Evans-blue and tagged chromium methods it has been found accurate provided complete mixing is achieved. Underwood *et al.*⁹ have laid down criteria for accuracy of an indicator as follows:

1. It should have no loss or diffusion.
2. The material must mix uniformly.
3. The identity of the tracer must be preserved with no metabolic change.
4. The tracer should be able to be measured readily and quantitatively.
5. The test substance must exist in the blood as a single molecular species.

RIHSA fulfills these criteria with the exception of the fact that it is lost into the extracellular fluid space. I¹³¹ has a half-life of eight days and disappears from the plasma at a rate of 6 per cent per hour. Many workers have found that there is a plateau prior to the disappearance of I¹³¹ from the plasma and that values taken within a 10 to 20 minute period, after allowing this time for proper mixing, are reproducible within a 6 per cent range.

The Volemetron itself is a semi-automatic isotope computing machine. It automatically subtracts the residue left in the syringe and in calculating the volume will take into consideration the radiation from pre- and post-mix samples, as well as the volume of the post-mix sample.

METHOD

The study was undertaken on twelve adult patients who were in hospital for a variety of medical or surgical reasons. They were given no pre-study sedation. Patients on any medication which might be expected to interfere with the study were excluded from it. All tests were carried out with the subject supine.

A clinical assessment of the adequacy or otherwise of the subject's blood volume was made on the history and physical examination. Conclusions were graded from 1 to 10. Ten points were awarded for full hydration and a clinically normal blood volume. Grades 1, 2, and 3 were reserved for decreasing degrees of severe volume depletion, 4, 5, and 6 for more moderate degrees, and 7, 8, and 9 for mild clinical hypovolaemia. The nature of this study however did not lend itself to the use of severely dehydrated patients.

A central venous pressure infusor catheter 21 inches long, manufactured by Sorenson Research, with a 15-gauge catheter through a 14-gauge needle, was introduced via a suitable vein in the antecubital fossa. The basilic vein was chosen over the cephalic whenever possible as less trouble was encountered advancing the catheter by that route. It was attached then via a three-way stopcock to an intravenous infusion of a balanced salt solution and to a manometer graduated in centimetres of water. The central placement of the catheter tip was assured by the observation on the manometer of fluctuations of 0.5-1 cm. H_2O with respirations and of 0.25 cm. H_2O with each heart beat. The zero level for the manometer was taken as the junction of the superior vena cava and the right atrium, projected into the body surface at the junction of the anterior one-third and the posterior two-thirds of the chest wall at the level of the third costal cartilage. This zero level was maintained by a device previously described by the author¹⁰ in order to assure a constant zero level and to give warning of any movements of the patient which might interfere with the validity of results.

A pre-mix sample of 8 ml. of blood was withdrawn now for the Volemetron determination and a further 16 ml. for haemoglobin, haematocrit, serum protein, serum creatinine, and serum electrolytes. Five microcuries of $RIHSA$, duly recorded by the Volemetron for amount of radioactivity, was injected then intravenously, the syringe was well flushed, the needle discarded, but the syringe itself preserved for residual isotope count. Twenty minutes were allowed for circulation and distribution of the $RIHSA$. Thereafter a post-mix sample was withdrawn. The isotope syringe, the pre-mix, and the post-mix samples now were taken to the Volemetron for determination of the blood volume. The instrument had previously been checked for accuracy by means of a standard isotope kit. Micro-haematocrit determinations were carried out on both the pre- and post-mix samples and double-checked. A correction of 0.96 for plasma trapping was applied, giving a final corrected venous haematocrit. From the reading on the Volemetron scale and from the corrected venous haematocrit the total blood volume was calculated. Separate plasma and red cell volumes were determined by means of tables supplied with the instrument.

After completion of the Volemetron determinations, three resting levels of central venous pressure and of blood pressure were obtained, the last being taken just prior to the chlorpromazine blocking test. Chlorpromazine was injected intravenously in a dose of 0.1 mg./lb. Serial blood pressure and central venous pressure readings then were taken as often as possible over the next 30 to 40 minutes.

RESULTS

An over-all review of results makes it obvious that clinical assessment of blood volume is inaccurate and misleading. Furthermore our results support the findings of Ryan and others⁶ who had failed to find any correlation between central venous pressure and blood volume. This applied equally whether blood volume results were related to a normal of 71 ml./kg. body weight (Fig. 1) or to a normal of 71 ml./kg. ideal body weight plus 10 ml. for each pound above the ideal (Fig. 2). On the other hand, when relating blood volume to normals based on body surface

FIGURE 1. Relation of resting central venous pressure (lower line) to blood volume (upper line) expressed as per cent of normal on the basis of 71 ml./kg. present weight.

FIGURE 2. Relation of resting central venous pressure (lower line) to blood volume (upper solid line) expressed as per cent of normal on the basis of ideal weight plus 10 ml./lb. excess weight. Dotted line: blood pressure drop after intravenous chlorpromazine against per cent of normal blood volume.

area, one finds that results are too low for the lower weight brackets but approach acceptable figures as weight and body surface area increase.

There is good evidence that a closer correlation of actual blood volume to the predicted normal could be obtained if that normal was determined on the basis of the ideal weight for a particular patient's sex, height, and age, with an extra 10 ml./lb. allowed for any excess weight above the ideal weight. This point is well illustrated by patient no. 12 (Fig. 3). The individual studied was a 42-year-old woman, 63 inches in height and weighing 178 pounds, with a surface area of 1.83 m.². Her haemoglobin was 13.4 gm. per cent and the corrected venous haematocrit was 36.7. Clinically she appeared normovolaemic and she had undergone no recent weight change, was active and healthy with no recent changes in her habits, and had entered hospital for an elective operation. Her total blood volume was determined as 4,140 ml. The calculated normal for a person weighing 178 pounds is 5,745 ml. and therefore this patient would appear to have a blood volume of only 74 per cent of normal. However, considering that her ideal weight would have been 125 pounds and allowing an extra 500 ml. of volume for the 50 pounds of overweight, the corrected normal blood volume would be 4,540 ml. On the basis of this calculation her blood volume would be 93 per cent of normal.

FIGURE 3. Patient no. 12: 42-year-old female. Weight: 178 pounds. Weight six weeks ago: 178 pounds. Weight six months ago: 175 pounds. Ideal weight: 125 pounds. Haemoglobin: 13.4 gm. per cent. Haematocrit: 36.7. Arrow: chlorpromazine 17 mg. i.v. Maximal mean blood pressure drop 0 per cent. Maximal central venous pressure drop 2 cm. H₂O. N denotes blood volume on basis of present weight. P denotes patient's blood volume. W denotes blood volume on basis of ideal weight. Cross-hatched areas represent red cell volume.

This would fit the clinical picture, the haemoglobin, the haematocrit, and the chlorpromazine blocking test more closely than the original calculation. The problem of what represents "normal predicted values" in respect to blood volume would appear to require further study and clarification.

An example of how haemoglobin and haematocrit can be misleading is presented by patient no. 1 (Fig. 4). This was a 64-year-old patient whose present weight was 155 pounds, but whose weight six weeks previously had been 163 pounds and six months previously 170 pounds. His haemoglobin was 11 gm. per cent and his venous haematocrit was 30.8. This patient had leukaemia, with a white blood count of 266,400. He appeared fully hydrated clinically and had an 11 per cent drop in blood pressure with chlorpromazine blocking. His total blood volume was 6,480 ml., with a red blood cell volume of 1790 ml. and a plasma volume of 4700 ml. His blood volume was 128 per cent of normal with normal red cell volume but markedly increased plasma volume. Without a blood volume determination this patient possibly might have received preoperative packed cells or whole blood because of the low haemoglobin and haematocrit. However, in essence this patient had a normal red cell mass with marked haemodilution due to an excess of plasma volume. This possibly was related to the extremely high white blood count.

FIGURE 4. Patient no. 1: 64-year-old male. Weight: 155 pounds. Weight six weeks ago: 163 pounds. Weight six months ago: 170 pounds. Ideal weight: 135 pounds. wbc: 266,400. Haemoglobin: 11.0 gm. per cent. Haematocrit: 30.8. Arrow: chlorpromazine 16 mg. i.v. Maximal mean blood pressure drop 11 per cent. Maximal central venous pressure drop 4.0 cm. H₂O. (N, P, and W as in Fig. 3.)

Patient no. 4 (Fig. 5) demonstrates the inadequacy of clinical judgment alone in determining blood volume and the difficulty of drawing firm conclusions from weight loss with regard to the adequacy or otherwise of total blood volume. This patient on clinical examination had mild jaundice, appeared dehydrated, and had a dry tongue; his tissues showed the effects of weight loss of 30 pounds during the last six months. He had flabby skin and loss of skin turgor. But contrary to expectations the total blood volume was 5,670 ml. with a red cell volume of 1770 ml. and a plasma volume of 3900 ml. This was 114 per cent on the basis of

FIGURE 5. Patient no. 4: 79-year-old male. Weight: 160½ pounds. Weight six weeks ago: 175 pounds. Weight six months ago: 190 pounds. Ideal weight: 151 pounds. Haemoglobin: 12.6 gm. per cent. Haematocrit: 35.0. Arrow: chlorpromazine 16 mg. i.v. Maximal mean blood pressure drop 13 per cent. Maximal central venous pressure drop 1.0 cm. H₂O. (N, P, and W as in Fig. 3.)

his ideal weight and 109 per cent on the basis of his present weight, and was exactly what would have been expected from his weight of six weeks ago. Again it appeared that regardless of weight loss the predicted blood volume should be assessed on the basis of ideal weight plus 10 ml./lb. for any excess weight above that ideal weight.

The chlorpromazine blocking test proved to be not only an inaccurate but also a dangerous test. Blood pressure decreases occurred in a range between 0 and 56 per cent after chlorpromazine blockade, and one must agree with Collins and Winnie⁷ that chlorpromazine will drop the blood pressure in the presence of significant hypovolaemia. However, in our series it was found to drop the blood

pressure out of proportion to any blood volume deficit in some patients, and on the other hand to fail in some patients to reveal the existing blood volume inadequacy by a corresponding decline of blood pressure. The central venous pressure during chlorpromazine blocking decreased by 0.5 cm. H₂O to 4 cm. H₂O but this did not seem in any way to correlate with the degree of hypovolaemia. The following are examples in point:

Patient no. 7 (Fig. 6) was a 19-year-old girl whose weight was 119% pounds, whose haemoglobin was 13.2 gm. per cent, and who had a corrected venous haematocrit of 35. The blood volume determination showed a blood volume of 3550 ml. or 92 per cent of the predicted normal. However, after chlorpromazine blockade the mean blood pressure fell by 42 per cent.

FIGURE 6. Patient no. 7: 19-year-old female. Weight: 119% pounds. Weight six months ago: 116 pounds. Ideal weight: 115 pounds. Haemoglobin: 13.2 gm. per cent. Haematocrit: 35.0. Arrow: chlorpromazine 12 mg. i.v. Maximal mean blood pressure drop 42 per cent. Maximal central venous pressure drop 2.0 cm. H₂O. (N, P, and W as in Fig. 3.)

Patient no. 11 (Fig. 7) was a 40-year-old man with a weight of 170% pounds, who six weeks ago had weighed 149 pounds, and whose ideal weight would have been 150 pounds. He had a haemoglobin of 15.6 gm. per cent and a haematocrit of 41.7. This patient had had a recent colostomy for diverticulitis and was re-admitted at the present time for resection of the affected colon. His total blood volume was 4150 ml. which was 76 per cent of predicted value on the basis of his present weight and 84 per cent on the basis of his ideal weight, yet the chlorpromazine blocking test was completely negative, there being no change in blood pressure.

FIGURE 7. Patient no. 11: 40-year-old male. Weight: 170½ pounds. Weight six weeks ago: 149 pounds. Weight six months ago: 155 pounds. Ideal weight: 150 pounds. Haemoglobin: 15.6 gm. per cent. Haematocrit: 41.7. Arrow: chlorpromazine 17 mg. i.v. Maximal mean blood pressure drop 3 per cent. Maximal central venous pressure drop 3.5 cm. H₂O. (N, P, and W as in Fig. 3.)

Patient no. 3 (Fig. 8) points to the possibility that the drop in blood pressure following chlorpromazine may be caused by some mechanism additional to adrenergic blockade. This was the case of a 64-year-old man with a haemoglobin of 12.2 gm. per cent and corrected venous haematocrit of 36.7, whose present weight was 161 pounds and whose ideal weight would have been 140 pounds. He had had some vague history of heart trouble without physical signs. His electrocardiogram showed trigeminal rhythm with fixed coupling. Physical examination was non-contributory. His total blood volume was 5,720 ml., which was 110 per cent of his predicted normal on the basis of his actual weight. Following chlorpromazine blocking he showed a drop in blood pressure of 25 per cent, looked pale, and felt sickly. The interesting fact here was that after the blockade and following the blood pressure drop his central venous pressure, after an initial slight fall to 2.5 cm. H₂O, gradually rose to 5.5 cm. H₂O, which was 2 cm. H₂O above control. This might imply direct depression of the myocardium from the drug.

Patient no. 10 (Fig. 9) is a good example of the danger inherent in the chlorpromazine blocking test. This 60-year-old man had been admitted for investigation of a lump in his neck. His weight was 126½ pounds against an ideal weight of 139 pounds, compared with a weight six months ago of 135 pounds.

FIGURE 8. Patient no. 3: 64-year-old male. Weight: 161 pounds. Weight six weeks ago: 160 pounds. Weight six months ago: 155 pounds. Ideal weight: 140 pounds. Haemoglobin: 12.2 gm. per cent. Haematocrit: 36.7. Arrow: chlorpromazine 16.0 mg. i.v. Maximal mean blood pressure drop 25 per cent. Maximal central venous pressure drop 0.5 cm. H₂O. (N, P, and W as in Fig. 3.)

The patient had not been well for some time but when seen was classified clinically as only mildly hypovolaemic. His tongue was moist, he was alert and up and about on the ward. His haemoglobin was 13.6 gm. per cent and his corrected venous haematocrit was 34.5. However, his total blood volume was found to be only 3,240 ml., with a red cell mass of 980 ml. and plasma volume of 2,260. This was 79 per cent of the predicted normal on the basis of his present weight and 72 per cent of the normal blood volume on the basis of the ideal weight. This patient developed dramatic hypotension after the chlorpromazine blockade. From a pre-block blood pressure of 110/70 mm. Hg the blood pressure at the end of the 10 minutes had fallen to 80/50 mm. Hg and at the end of 13 minutes was 50/30 mm. Hg. At that time he was responding barely to questioning and his colour was deathly gray. Within one further minute a blood pressure could no longer be detected. Methoxamine which had been drawn up into a syringe prior to the chlorpromazine blocking test was given intravenously in a dose of 20 mg. and the intravenous fluids were allowed to run as quickly as possible through the 15-gauge central venous pressure catheter. One minute later the blood pressure had risen to 60/20 mm. Hg. Three minutes later another 12 mg. of methoxamine were given intravenously. By this time oxygen by nasal catheter had been started. Six minutes after the first dose of methoxamine the blood pressure was 90/60 mm. Hg and the patient subsequently made an uneventful recovery. The central venous

FIGURE 9. Patient no. 10: 60-year-old male. Weight: 126½ pounds. Weight six weeks ago: 126 pounds. Weight six months ago: 135 pounds. Ideal weight: 139 pounds. Haemoglobin: 13.6 gm. per cent. Haematocrit: 34.5. Arrow: chlorpromazine 12.5 mg. i.v. Methoxamine 20 mg. i.v. at 14 min. and 12 mg. i.v. at 18 min. Maximal mean blood pressure drop 56 per cent. Maximal central venous pressure drop 2 cm. H₂O. (N, P, and W as in Fig. 3.)

pressure went from a pre-blocking level of 4.5 cm. H₂O to 2.5 cm. H₂O at the ten-minute point. Due to the attention being paid to the resuscitative measures no further central venous pressure readings were recorded until six minutes after the methoxamine had been given. At that time it was 7.0 cm. H₂O. This case demonstrated the extreme danger associated with alpha blockade in the presence of marked hypovolaemia and also the inability, on a clinical basis, to predict such a case.

No obvious correlation could be demonstrated between blood volume on the one hand and serum proteins, electrolytes, or creatinine on the other hand.

SUMMARY AND CONCLUSIONS

A short review is presented of the various means available to determine blood volume in man. On the basis of our findings, it is clear that there is no reliable way of clinically assessing the adequacy or otherwise of the circulating blood volume. No relationship could be demonstrated between serum proteins, serum electrolytes, creatinine, or central venous pressure and blood volume. Haemoglobin and haematocrit determinations by themselves also are of limited value, but if their changes are related to baseline readings, which include a reliable

blood volume determination, then certain conclusions can be drawn from changing haematocrit and haemoglobin. The chlorpromazine test also fails to be a reliable index of blood volume in that it may not affect the arterial blood pressure in cases of moderate hypovolaemia and on the other hand may cause hypotension in the presence of a normal circulating volume. This latter effect can be explained most readily by the multiplicity of the pharmacological impact of that agent.

The only reliable methods of determining circulating volume (and this also has its limitations) are those based on indicators of which the RHSA technique by means of the Volemetron is the simplest. This method allows calculation of plasma and red cell volume indirectly through the determination of mixed venous haematocrit. For all practical purposes therefore this is the method of choice at the present time, bearing in mind that the accuracy of results will depend upon adequate mixing, which under some clinical conditions cannot be assured. Of course, blood volume determined by whatever method must be related to a "normal predicted value" for that particular individual. There still is much controversy whether the normal predicted value should be based on present weight, on past weight in the case of weight loss, or on ideal weight with corrections being made for any deviation from that ideal. Until this question is resolved any percentage deviations from predicted normals are open to serious doubt.

In view of the fact that clinical impressions are so misleading it is recommended that blood volume determinations be carried out in all cases in which there is the slightest doubt as to the state of the circulating blood volume.

RÉSUMÉ

On passe brièvement en revue les différents moyens à notre disposition pour déterminer le volume sanguin chez l'homme. D'après nos résultats, il est clair qu'il n'y a pas de moyen sûr de savoir cliniquement que le volume de sang circulant est suffisant ou non. On n'a pas pu établir de rapport entre les protéines du sérum, les électrolytes du sérum, la créatinine ou la pression veineuse centrale et le volume sanguin. Les taux d'hémoglobine et d'hématocrite ont en soi une valeur limitée; mais si leur variation est rapportée à des données de base, ce qui inclut un bon dosage du volume sanguin, alors on peut tirer certaines conclusions des variations de l'hémoglobine et de l'hématocrite. L'épreuve à la chlorpromazine n'est pas non plus un indice certain du volume sanguin : elle peut ne pas influencer la pression artérielle dans les cas d'hypovolémie légère, et d'un autre côté elle peut provoquer une hypotension alors que le volume circulant est normal. Ce dernier effet peut être facilement expliqué par la complexité de l'action pharmacologique de cet agent.

Les seules méthodes fiables de déterminer le volume circulant (et c'est encore relatif) sont celles qui sont basées sur des indicateurs : la plus simple est la technique RHSA au moyen du Volemetron. Cette méthode permet de calculer le volume du plasma et des globules rouges indirectement par le dosage de l'hématocrite veineuse.

Par conséquent, pour toutes fins pratiques, c'est actuellement la méthode de choix; il ne faut pas oublier cependant que la précision des résultats dépendra de la perfection du mélange, ce qui ne peut pas être assuré dans certaines conditions cliniques. Sans doute, quelle que soit la méthode utilisée, le dosage du volume sanguin doit se faire par rapport à une normale pré-établie pour chaque sujet. On ne s'accorde pas encore sur cette normale pré-établie : devrait-elle être basée sur le poids actuel, sur le poids antérieur en cas de perte de poids, ou sur le poids idéal en effectuant la correction nécessaire pour toute déviation de ce poids idéal? Tant que cette question ne sera pas résolue, toute déviation de cette normale pré-établie peut engendrer des doutes sérieux.

Du fait que les impressions cliniques conduisent si facilement à l'erreur, on recommande de déterminer le volume sanguin dans tous les cas où il y a doute sur l'état du volume sanguin circulant.

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