Canad. Med. Ass. J.
July 16, 1966, vol. 95

GENERAL PRACTICE

Estimation of Blood Loss in a Small Community Hospital

JAMES H. MACLEOD, B.Sc., M.D., C.M., F.A.C.S.,* *Liverpool, N.S.*

Three methods of blood loss estimation which are simple, accurate and cheap are: (1) weighing of sponges; (2) estimation of blood volume with Evans blue dye and (3) measurement of central venous pressure (CVP).

Weighing of sponges is a valuable operating-room procedure although it has certain defects some of which are described. The Evans dye method is used chiefly in preoperative assessment when hypovolemia is suspected but serial estimations are feasible and can be performed in 45 minutes. Measurement of CVP, however, is the best single criterion of effective blood volume in relation to cardiac functional capacity and is the best guide to blood and fluid requirements. A simple "homemade" device for making serial CVP determinations, incorporating a manometer and a zero level, is described.

These methods of blood loss estimation do not supersede the traditional methods of the clinical assessment of the surgical patient, but are valuable adjuncts to such assessment.

Il existe trois méthodes simples, précises et économiques d'évaluer les pertes de sang: (1) peser les éponges, (2) évaluer le volume du sang au moyen du colorant bleu d'Evans et (3) mesurer la pression veineuse centrale (PVC).

La pesée des éponges est une méthode précieuse dans la salle d'opération, bien qu'elle soit entachée de certains défauts qu'expose l'auteur. La méthode du colorant d'Evans a son principal intérêt quand il s'agit d'une évaluation pré-opératoire, dans les cas où on soupçonne une hypovolémie. Cependant, comme le souligne l'article, il est possible de procéder en 45 minutes à des évaluations en série. La mesure de la PVC reste encore le meilleur critère d'évaluation du volume sanguin par rapport à la capacité fonctionnelle du cœur et le meilleur guide pour estimer les besoins de sang et de liquides. L'article explique comment "bricoler" un dispositif simple destiné à mesurer la PVC en série et qui comporte un manomètre et un niveau zéro.

Sans doute, ces méthodes d'évaluation des pertes de sang ne remplacent-elles pas les moyens traditionnels d'évaluation clinique du candidat à l'opération, mais au moins elles constituent de précieux adjuvants à cette fin.

MORE surgery and more extensive surgery is now being done in small community hospitals. Although complicated and expensive methods of blood volume estimation are not available in such hospitals, blood loss should be assessed. This can be done simply, at low cost, and yet with a reasonable degree of accuracy.

Knowledge of the degree of blood loss enables early and accurate replacement, which in turn requires less blood than the treatment of shock that is well established.[1, 2]

Even if hypovolemia is corrected, a period of hypotension and poor tissue perfusion carries with it a significant risk of renal and myocardial complications, especially in elderly and poor-risk patients. In addition, these patients tolerate overloading of the circulation poorly.[3]

A stated blood loss in infants and small children represents a relatively higher percentage of the total blood volume than in adults, and what may be a modest loss in the adult may be a highly significant loss in the pediatric patient.[4]

A few years ago at Queens General Hospital, Liverpool, N.S., the current methods of blood loss estimation were re-evaluated. The recording of pulse rate, blood pressure, skin colour and temperature are valuable indicators of blood volume status and should be considered first; but there is no *single* reliable clinical sign of *impending* shock due to blood loss, especially in anesthetic and post-anesthetic states. By the time shock is recognized as such, it is often well established and a large blood volume deficit may have occurred before it is suspected.[5, 6] There is no dependable correlation between hemoglobin or hematocrit and the amount of blood loss; and serial determinations are of little value in the actively bleeding patient.[2, 5, 8] Urinary output would be an excellent guide to blood volume but for the necessary latent period involved in urine formation.

Because of these shortcomings, three reasonably accurate alternative methods of blood loss estimation have been instituted which, although useful in hospitals of any size, are particularly suited to the small hospital. These methods are the subject of the present communication.

I. GRAVIMETRY

The gravimetric method refers to the weighing of sponges in the operating room. Many variations of this method have been described,[1, 3, 6] but the following method is probably the simplest and best for the small hospital (Fig. 1).

The weight of sponges is quite constant; for example, 12″ x 12″ sponges and 8″ x 36″ packs weigh respectively 16 and 26 g. The number of these used during an operation is multiplied by their respective dry weights and the result is subtracted from the total weight of the blood-stained sponges to give the weight of the blood lost, assuming that each gram equals 1 c.c. of blood.

Presented at the Atlantic Regional Meeting of the Royal College of Physicians and Surgeons of Canada, Saint John, N.B., October 7, 1965.

*P.O. Box 1060, Liverpool, Nova Scotia.

If suction has been used, the blood in the suction bottle must be included. Furthermore, evaporation is an important factor. The sponges should be placed on the tray and weighed directly, or placed in a waterproof bag until they are weighed.

Dry sponges are used in this hospital. Blood loss can still be measured if the sponges are moistened before use by measuring the saline.[7] This, however, complicates a simple procedure and increases the chance of error. In any case, gentleness and good surgical technique are far more important than the fact that the sponges are wet or dry.

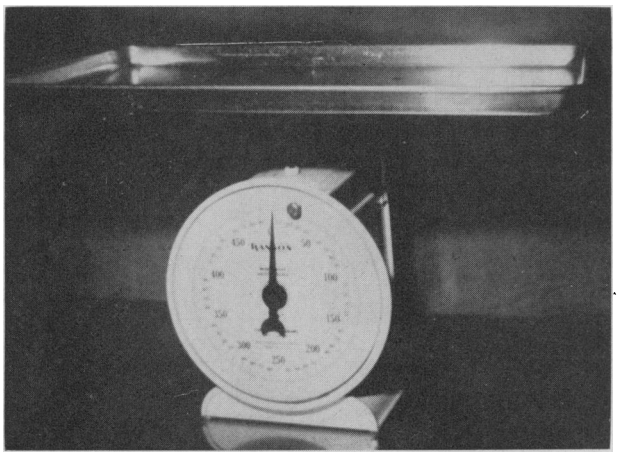

Fig. 1.—The sponges are weighed on an ordinary dietetic scale to which a light metal tray has been added. Each gram of blood is considered to represent 1 c.c.

Blood loss during a routine procedure may not be great, but any routine procedure may become prolonged and involve extensive dissection. Prolonged minor blood losses may become dangerous.[1] The longer and more extensive the procedure, the greater the tendency to error in blood-loss estimation. Actual blood loss is nearly always greater than that estimated by the surgeon.[3, 5, 7] The weighing of sponges is now routine at the Queens General Hospital and estimations of blood loss are obtained quickly.

This method also has its shortcomings; for example, blood on the drapes, gowns, towels and instruments is difficult to measure. In addition the method does not measure a number of other significant forms of blood loss: that lost into the tissues, that removed with the surgical specimen, and that immobilized in vessels proximal to ligature. Finally, it does not take into account preoperative or postoperative blood losses, either of which may be appreciable.[3, 7]

Despite these limitations, the weighing of sponges is a simple, reasonably accurate procedure by means of which blood loss can be recorded quickly at any time during the operation. However, it must be stressed that the blood loss so measured is the minimal amount required for replacement.[1] The loss indicated by gravimetry is estimated to be 75% of the true blood loss.[9]

II. Measurement of Central Venous Pressure

There has been a recent upsurge of interest in the measurement of central venous pressure, and it is a very useful adjunct to the weighing of sponges. It also gives some indication of the degree of preoperative blood loss and hence of postoperative blood and fluid requirements. It is probably the best available guide to the maintenance of adequate circulating blood volume.[7, 9] It gives a far earlier indication of diminished blood volume than blood pressure measurements and is more reliable in many respects than blood volume determinations[3, 6] (Fig. 2).

Central venous pressure (CVP) depends upon the pump action of the heart, the circulating blood volume, and the vascular tone.[3, 10] A deficiency of any one or any combination of these factors will have an immediate effect on the central venous pressure. For example, deterioration of cardiac function will cause an elevation in CVP. On the other hand, an inadequate blood volume or enlargement of the vascular space will cause a diminution in CVP. Restoration or maintenance of adequate circulation requires the co-ordinated supporting of these three determinants of CVP.[3, 11]

Measurement of CVP is one of the simplest, most convenient and most reliable indices of the circulating blood volume relative to the heart action.[3, 6, 12] A low CVP (0 to 6 cm. of water) indicates that the blood volume is low in relation to cardiac capacity and that replacement with blood or blood volume expanders is needed to increase the presystolic volume and the length of the heart muscle fibres, thereby improving cardiac output.

A continuing low CVP ensures that the circulatory system is not being overloaded and that replacement should continue. In such cases large quantities of blood or fluids can be given safely and may be needed, because, even if estimates of blood volume are within normal limits, the replacements required in shock may be far greater than the "normal" blood volume.

If bleeding is controlled and repeated transfusions have had only a transient effect on the shock, on the cardiac output and on the CVP, it can be concluded that peripheral pooling has occurred. In such cases judicious use of vasopressors or other agents may be indicated.

An elevated or rising CVP (above 15 cm.) with hypotension, in the absence of increased intrathoracic pressure, indicates that the blood volume is high relative to the cardiac capacity and that cardiac failure is imminent. Further replacement may be hazardous, and such measures as improved ventilation, correction of acidosis or electrolyte imbalance, control of arrhythmias, or administration of vasopressors or myocardial stimulants must be considered before proceeding. The measures noted above will cause more forceful ventricular contraction.

Canad. Med. Ass. J.
July 16, 1966, vol. 95

Hypotension in the presence of a normal CVP (8 to 14 cm.) calls for a cautious trial of blood volume expanders, further observation and careful interpretation.

The *trend* of central venous pressure and the *response to therapy* are often much more significant than the actual reading.[3, 8, 11]

Indications.—This method is used whenever the circulation is unstable or when problems related to the cardiovascular system or fluid balance are anticipated.[3]

In this institution it is used in all elderly or poor-risk patients undergoing extensive operations and in all patients in whom there has been or may be large blood or fluid losses.

Technique.—A polyethylene catheter is advanced through a needle placed percutaneously (or by cutdown if necessary) into the external jugular vein. The pressure in this vessel is the same as in the superior vena cava because there are no intervening valves. A free flow between the central venous system and the manometer is indicated by fluctuation of the fluid column with breathing and with the heart beat.

Peripheral venous pressure is not a reliable index of CVP for several reasons, chiefly the interposition of valves between the right atrium and the point of measurement, and the element of peripheral venospasm.[6, 13]

The external jugular vein is a relatively simple vein to catheterize, and we have had no complications such as have been encountered at other sites.[3, 6] To keep it from breaking off and migrating, the catheter should be taped securely at its junction with the needle.

The simplest means of measuring CVP is to attach a spinal-fluid manometer to the catheter by means of a three-way stopcock and to run an intravenous drip through the system continuously. A water manometer for monitoring CVP can be constructed by adding a second intravenous tubing to the regular intravenous administration system and placing this "sidearm" against a centimetre scale. I have modified this method (Fig. 2) using a combination square (cost about $3.50) with a scale and a level. This allows the zero point to be levelled quickly and accurately with the midaxillary line (which is taken to indicate the level of the right atrium with the patient supine and the head lowered). The central venous catheter is used for blood or fluid administration and the manometer tube is kept closed except when measuring CVP. Readings may be taken as often as desired by clamping the regular intravenous tubing and opening the manometer tube.

Central venous pressure monitoring is superior to serial blood volume determinations in the following respects:

(1) A blood volume determination becomes obsolete very quickly in situations where blood volume is unstable (i.e. continuing hemorrhage).

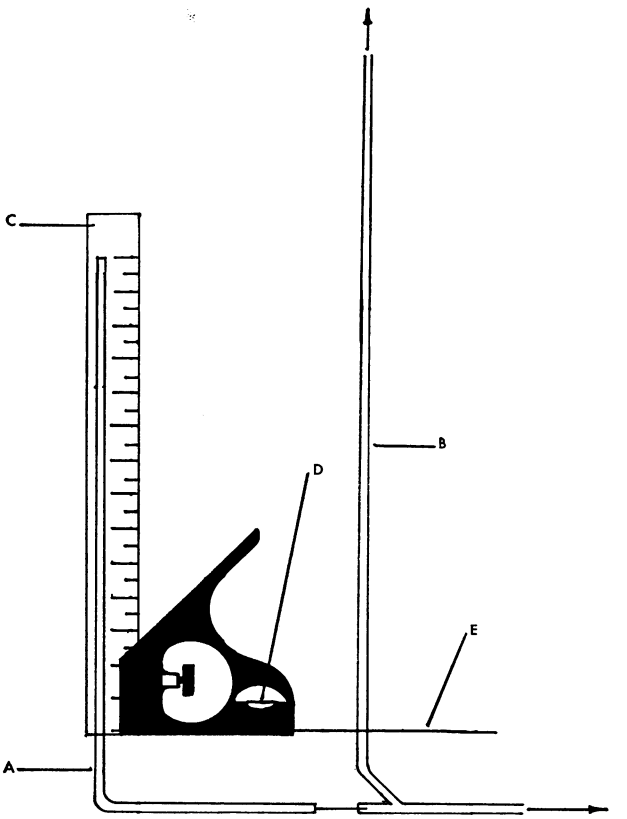

Fig. 2.—The manometer tubing (A) is attached to the intravenous tubing (B) and placed against the ruled portion (C) of the combination square. The zero point is brought level with the mid-axillary line using the bubble level (D). A Kirschner wire (E) may be attached to ensure greater accuracy in alignment.

(2) The frequency with which blood volume determinations can be repeated is limited, and with repetition the error in the determination increases owing to residual circulating radioactive tracer.

(3) "Normal" blood volume in terms of the patient's height and weight may be significantly higher or lower than the patient's optimal blood volume.[3, 6, 11]

CVP monitoring is a continuous procedure and gives an indication of the patient's effective blood volume and the heart's ability to handle the circulating blood volume. It is simple, accurate and cheap and can be used in small or large hospitals, day or night.

III. BLOOD VOLUME DETERMINATIONS WITH EVANS BLUE DYE

In spite of the previous criticisms of blood volume determination, the Evans blue dye method is valuable for determining the status of the intravascular compartments, especially in the preoperative surgical patient who may have a chronic, compensated oligemia. Blood volume, however, is now generally estimated with radioactive isotopes, and the Evans blue method has been largely abandoned as too cumbersome. Nevertheless, its accuracy is equal to that of other methods.[14, 16]

After repeated determinations on normal volunteers to confirm the accuracy of the procedure, we

have used the Evans blue technique in a number of patients suffering from significant blood loss.

Method.—Evans Blue Injection (Warner-Chilcott) 0.5% solution (5 mg./ml.) is used as described in the manufacturer's brochure; however, only 2.5 ml. is injected rather than 5 ml. as recommended by the manufacturer, and the stock standard is made up in a dilution of 1 to 1000 rather than 1 in 500.

More frequent estimations can be done with radioactive isotopes and less difficulty is encountered with turbidity and hemolysis; these factors have caused us no trouble, but dye accumulation prevents repeated determinations. At any rate, CVP determinations are a better method of continuous monitoring. In this institution blood volume determinations are reserved for preoperative assessment although an occasional determination is done during or after blood loss.

Serial Evans blue determinations are feasible, although the accumulation of residual dye in the circulation contributes to error.

Excess dye causes temporary staining of the tissues and imparts a bluish tinge to the skin. However, if serial determinations are necessary the temporary discolouration is a minor consideration.

A separate blood volume tray is now maintained in the hospital laboratory. A plasma volume determination can be obtained within 15 minutes but the hematocrit requires 30 minutes; that is, 45 minutes is needed for a blood volume determination. If a microhematocrit is available, the total time would be under one-half hour, which compares very favourably with other methods of blood volume estimation.

The most important and difficult part of the procedure is the extreme accuracy required in all measurements. Each laboratory should establish its own normal limits.[15, 16] The method should be used frequently enough so that the technicians can gain experience and become proficient.

SUMMARY

Three methods of blood loss estimation are described: weighing of sponges, measurement of central venous pressure and determination of blood volume with Evans blue dye. These methods are not mutually exclusive. One may complement another, and on occasion all three may be of value in the same patient. These methods do not supplant the time-honoured techniques of clinical assessment, such as estimations of blood pressure, pulse rate, urine output and others, but they are additional valuable aids. None is new, but all are of value. Their use is not restricted to the small hospital, but certain features of these procedures recommend them particularly to such institutions, i.e. their accuracy, simplicity and low cost. Blood loss should not be the subject of guesswork when it can be estimated scientifically and accurately, cheaply and quickly. Hemorrhagic shock is, after all, much more easily prevented than cured.

REFERENCES

1. BIRD, S. B. AND MACLEOD, J. H.: *Nova Scotia Med. Bull.*, 43: 115, 1964.
2. SALTZSTEIN, H. C. AND LINKNER, L. M.: *J. A. M. A.*, 149: 722, 1952.
3. WILSON, J. N. *et al.*: *Arch. Surg. (Chicago)*, 85: 653, 1962.
4. DAVENPORT, H. T. AND BARR, M. N.: *Canad. Med. Ass. J.*, 89: 1309, 1963.
5. COLLER, F. A., CROOK, C. E. AND IOB, V.: *J. A. M. A.*, 126: 1, 1944.
6. HUGHES, R. E. AND MAGOVERN, G. J.: *A.M.A. Arch. Surg.*, 79: 238, 1959.
7. BONICA, J. J. AND LYTER, C. S.: *Amer. J. Surg.*, 81: 496, 1951.
8. BOROW, M. *et al.*: *Surg. Gynec. Obstet.*, 120: 545, 1965.
9. CACERES, E. AND WHITTEMBURY, G.: *Surgery*, 45: 681, 1959.
10. STARLING, E. H.: Principles of human physiology, 4th ed., Lea & Febiger, Philadelphia, 1926, p. 781.
11. MACLEAN, L. D. *et al.*: *Surg. Gynec. Obstet.*, 120: 1, 1956.
12. MACLEAN, L. D.: *Ibid.*, 118: 594, 1964.
13. WILSON, J. N. AND OWENS, J. C.: *Surg. Forum*, 12: 94, 1961.
14. MOLLISON, O. L.: Blood transfusion in clinical medicine, 3rd ed., Blackwell Scientific Publications Ltd., Oxford, 1961, p. 49.
15. WIKLANDER, O.: *Acta Chir. Scand.*, Suppl. 208: 1, 1956.
16. DAGHER, F. J. *et al.*: *Advances in Surgery*, 1: 69, 1965.

PAGES OUT OF THE PAST: FROM THE JOURNAL OF FIFTY YEARS AGO

THE ETIOLOGY OF SOLDIER'S HEART

The "irritable heart of the soldier" is no new condition, but was recognized as far back as the American Civil War, when it attracted wide attention. A classical description, corresponding in all respects to the picture as presented to-day is given by Dr. Hathorn in the *American Journal of Medical Sciences* for 1864, and in the same journal for 1871, Da Costa reviewed the subject upon the basis of a series of three hundred cases collected in a hospital in Philadelphia. The condition is characterized by signs of vasomotor instability, aching precordial pain, a sense of exhaustion amounting often to giddiness or faintness, general malaise, rapid pulse on exertion, slight breathlessness, at times slight œdema of the feet, mental depression, and nervous irritability. There is usually a slight rise of temperature especially at the onset, which is often with diarrhœa and other digestive disturbances. It is to be understood that only the most serious cases of cardiac instability are sent to England. Mild cases are looked after in France.

An interesting discussion upon the etiology of soldier's heart has occupied several of the British journals during the past six months. Sir James Mackenzie with W. Bezley Thorne, R. McD. Wilson, and others, regard it as one symptom of a general physical exhaustion, the result in the majority of cases of a latent infection which becomes active under the effect of strain or shock and produces the general effects of a toxæmia, which yields to the raising of the resistive powers of the individual by good hygiene, fresh air, and cheerful occupation. This view is supported by the experience at the Hampstead Hospital since its organization where the accumulation of facts is tending to show that the so-called soldier's heart results in nearly 80% of the cases from infectious disease, of which rheumatic fever holds the leading place. But it is rendered doubtful by the experience of Dr. R. D. Rudolph, of Toronto, who writes us that in the Medical Division of No. 2 Canadian General Hospital in France, of which he was in charge, every well marked case of cardiac instability was tested for the presence of streptococci with a negative result in every case.—Editorial, *Canad. Med. Ass. J.*, 6: 616, 1916.