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Perioperative Assessment of Blood Loss-A Comparison Between Modified Gross Formula and Clinically Assessed Method

KEYWORDS

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ABSTRACT ***Background :*** *Anesthesiologists often rely on clinical estimation of blood loss alone to guide the transfusion of whole blood in the perioperative period because other methods of estimations either may not be practical or available at all the times, but these estimations suffer from large interobserver variability and poor repeatability so this was planned to assess the accuracy of clinically estimated perioperative blood loss.* ***Methodology:*** *Normovolemia was maintained throughout the procedure. Fasting and maintenance fluids were given using appropriate crystalloids and any blood loss was replaced with colloid (eg. 6% hydroxyl ethyl starch). The clinically Estimated Blood Loss (EBL) and time were noted; also the fluid therapy up to the time of estimation was recorded.* ***Results :*** *According to Bland and Altman's method of assessing agreement between two methods of clinical measurement5, the difference between the measurements will reflect the accuracy of the measurement. For each patient the preoperative haematocrit, body weight, duration of blood loss, percentage of circulating blood volume lost was studied and compared to this difference in blood loss. The P value (P>0.05) for these suggests that the accuracy of clinically estimated blood loss does not appear to depend on the preoperative haematocrit, body weight, duration of blood loss or the percentage of blood volume lost. The average blood loss was between 135ml and 1002 ml with a mean of 614.48 ml and a standard deviation of 231.80ml.* ***Conclusion :*** *From this study we conclude that the practice of perioperative blood transfusion is a balancing act between clinical benefits and the adverse transfusion outcomes where we have to rely on definite laboratory values or point of care estimations of Hematocrit and on clinical estimation of blood loss alone.*

Introduction:
Anesthesiologists often rely on clinical estimation of blood loss alone to guide the transfusion of whole blood in the perioperative period because other methods of estimations either may not be practical or available at all the times, but these estimations suffer from large interobserver variability and poor repeatability. In healthy individuals undergoing surgery with significant blood loss, under transfusion has been associated with risks of increased perioperative morbidity and delayed recovery in the postoperative period. In patients with respiratory disease and those with compromised cerebral and/or coronal circulations, the risks of acute perioperative anemia are significant. [1, 2,3] Changes in red cell volume during surgical operation can only be estimated by using hematocrit or hemoglobin levels.
Severe formulae have been derived for estimating allowable pre-transfusion blood loss. This linear formula implies that the fractional decrease in hematocrit is equal to the fraction of the total blood volume that has been lost. This would be true if all of the shed blood had the initial hematocrit. However, intravascular volume usually is maintained prior to blood transfusion by administration of crystalloids; hematocrit therefore should decrease gradually. Because each millimeter of shed blood contains progressively less hemoglobin, the above formula overestimates the hemoglobin loss. Inconsistencies may result. Bourke and Smith discussed this problem in 1975 and described the problem of isovolemic hemodilution in terms of the differential equation; dH/dVL = -H/EBV

The solution of this equation with initial H=HO and initial VL=0 is, 0-subscript indicating initial condition; $VL = EBV \times \log (H_O/H_F)$. [4,5] This formula, also described by Ward et al. has been shown to correspond accurately to measured blood. However, because it requires the use of the natural logarithm function, it is not suited to routine use. Bourke and Smith attempted to overcome this logarithm, but their formula was cumbersome and difficult to remember. Gross derived a formula approximating the logarithm of Bourke and Smith equation.$VL = BV [Hct_O – Hct_F] / Hct_{AV}$

So this study was planned to assess the accuracy of clinically estimated perioperative blood loss, which is often alone used as a guide line for transfusion of whole blood in the perioperative period, by comparing the clinically estimated blood loss with the blood loss estimated by using modified Gross formula. [6,7]

Materials & Methods: Following approach of the institutional research and ethics committee and informed consent from the patients, 50 patients were selected randomly from the OR list who met the following criteria: Major elective general surgical, orthopedic and gynecological procedures for which blood was cross-matched. ASA I & II. Patient undergoing cardiac surgery and other surgeries where clinical estimation of blood loss is not routinely performed (because of extracorporeal or large fluid shifts). Patients whose BMI>25 (obesity makes blood volume estimation from body weight inaccurate) Patients with severe anemia (patients with hematocrit <21% would not normally be allowed to lose blood prior to transfusion). Patients with sudden and/ or massive blood loss (as they require whole blood transfusion in a emergent situation often before blood loss could be estimated or hematocrit could be sent). ASA III and above were excluded from the study.

The consultant anesthesiologist was informed about the study and a proforma was made available to him. Age, Sex, Body weight, preoperative hematocrit, diagnosis and proposed surgery were entered in the proforma. Normovolemia was maintained throughout the procedure. Fasting and maintenance fluids were given using appropriate crys-

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talloids and any blood loss was replaced with colloid (eg. 6% hydroxyl ethyl starch). At any point in time perioperatively, the attending anesthesiologists clinically estimated the blood loss upto then. Simultaneously, a blood sample was sent to the laboratory and the hematocrit was tested. No blood was transfused till the sample was drawn. The clinically Estimated Blood Loss (EBL) and time were noted; also the fluid therapy up to the time of estimation was recorded. Using a standard automated analyzer the hematocrit was tested and the result was conveyed to the anesthesiologist within 5 minutes.

In this study in all the patients, the blood loss was estimated both by clinical method (clinically estimated blood loss) and by modified Gross formula, which was used for calculating blood loss.Clinical methods of blood loss assessment include: The blood soaked mops and gauze pieces were weighed preoperatively and postoperatively after usage and the amount of blood they carried is obtained by simple subtraction of preoperative weight from the postoperative weight of the individual mop pad and gauze separately. Then the amount of blood lost to them was obtained by simple Rains factor. According to Rains factor 1 gram = 1 ml, but for operation such as radical mastectomy or partial gastrectomy its taken as 1 gram = 1.5 ml and for prolonged surgery via large wounds, as in abdominothoracic or abdominoperineal operations it is taken as 1 gram = 2 ml of blood loss. Measuring the suctioned blood from the suction bottles, subtracting irrigation volume of saline if used. Visually estimating the blood loss onto the drapes and in and around the operative field. Then the sum of all weighed mop pads, gauze and visually estimated blood gives the total blood loss at the end of the surgery. [8,9,10]

The tome from the induction of Anesthesia to the time of blood loss estimation was noted and also the volume and types of intravenous fluid given before and after the estimation was recorded. The total blood loss and the total duration of surgery were noted in the proforma. The postoperative hematocrit was then followed up.

The Actual Blood Loss (ABL) was calculated from the modified Gross formula Therefore for each patient the clinically Estimated Blood Loss (EBL) and the calculated Actual Blood Loss (ABL) is used to calculate the Difference in Blood Loss (DIFF-BL) which was the numerical difference between the Actual and the Estimated Blood Loss.

Observation & Results

Among the 50 patients there were 35 females and 11 males. Their ages were between 30 and 75 years. The body weights ranged from 30 to 80 kgs (mean = 50.46 kgs and standard deviation of 8.06 kgs). The preoperative Hematocrit ranged from 26 to 42% (mean = 32.12% and standard deviation of 4.28%). The specialty represented were General Surgery, Orthopedics and Gynecological surgeries with 5, 6 and 39 patients respectively.

In 16 of the 50 cases the Estimated Blood Loss exceeded the Acute Blood Loss. In these cases the clinical judgement has estimated that the blood loss was more (than it actually was). These cases would have a negative difference in Blood Loss (or difference in blood loss <0). These can be grouped together as cases of overestimation and account for 32% of the study.

Of the remaining 34 cases (64% of the study), the Acute Blood Loss (ABL) exceeded the Estimated Blood loss (EBL). Here the underestimation of blood loss is reflected by the difference in Blood loss being positive (difference in blood loss >0). The range of difference in Blood Loss was between -378ml (overestimation) and +735 ml (underestimation). The mean of the differences was +181.82 ml and standard deviation was 276.27 ml.

According to Bland and Altman's method of assessing agreement between two methods of clinical measurement[5], the difference between the measurements will reflect the accuracy of the measurement. For each patient the preoperative haematocrit, body weight, duration of blood loss, percentage of circulating blood volume lost was studied and compared to this difference in blood loss. The P value (P>0.05) for these suggests that the accuracy of clinically estimated blood loss does not appear to depend on the preoperative haematocrit, body weight, duration of blood loss or the percentage of blood volume lost. The average blood loss was between 135ml and 1002 ml with a mean of 614.48 ml and a standard deviation of 231.80ml.

Table 1: Showing the t-test Body Weight vs ABL

	Number	Mean	SD	t-value	P value
Body weight	50	50.46	8.06	14.439	0.001 (0.01)
ABL	50	707.42	325.44		

P<0.001

Table 2 : Showing the t-test Blood volume vs ABL

	Number	Mean	SD	t-value	P value
Blood Volume	50	3159.40	675.87	28.935	0.001 (0.01)
ABL	50	707.42	325.44		

The Average Blood Loss is used to group patient's into groups with loss less than 400ml (12 Patients), 400 to 800ml (23 patients) and losses more than 800ml (15 patients). There are then compared to the difference in Blood Loss.. The P value<0.05 also confirms that there is significant difference between the patients when the average blood loss is compared to the difference in blood loss.

Table 3 : Average Blood loss and difference in Blood loss

Average Blood Loss	Difference in Blood Loss			Total
	<0 ml	0-400 ml	>400ml	
<400 ml	6 (12.0%)	6 (12.0%)	0	12 (24.0%)
400-800 ml	8 (16.0%)	9 (18.0%)	6 (12.0%)	33 (66.0%)
>800 ml	2 (4.0%)	3 (6.0%)	10 (20.0%)	15 (30.0%)
Total	16 (32.0%)	18 (36.0%)	16 (32.0%)	50 (100.0%)

Average Blood loss and difference in Blood loss Bland and Altman Plot

When the Average Blood Loss is plotted on the X-axis against the Difference in Blood Loss on the Y-axis we observe the spread of data for all the 50 patients. Here we see that as the Average Blood Loss increases, the values are scattered further away from the "0" point on the y-axis. This signifies that there is an increase in the difference between the actual and estimated Blood Loses as the average blood loss increases. The calculated 99% confidence intervals were -378ml and to +735ml.

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Discussion:

Blood is finite resource with a limited shelf life and is associated with considerable processing costs[5]. Utilization of this resource needs critical review to identify areas of overuse and thus reduce risk to patient and hospital costs. Risks of homologous transfusion vary in type and severity. Morbidity and mortality may result from either an immunologically mediated reaction or a transmitted infection.

Anesthesiologists often rely on clinical estimation of blood loss alone to guide the transfusion of Red Blood Cells (RBCs) in the perioperative period. But these estimations suffer from large interobserver variability and poor repeatability. The extent of blood loss and response to transfusion is reflected in the changes in the hematocrit [11,12]. This change may be used to calculate the Actual Blood Loss during suitable formula. The design of this study was based on a modification of the Gross formula[3,13,14] that was originally derived to calculate the allowable Blood Loss. This takes into account the ongoing hemodilution that occurs, assuming that normovolemia is maintained. In this study normovolemia was maintained throughout and no RBCs were transfused between the perioperative hematocrit and the clinical estimation.

This study has shown that using clinical estimation alone to guide transfusion is inadequate. The interclass correlation coefficient for the data was 34% further confirming poor agreement between the Actual Blood Loss and estimated blood loss. The 95% confidence intervals (-719.939 ml to +1265.619 ml) suggest that clinical estimation alone may result in unacceptable under or over transfusions.

Perioperative transfusion triggers for RBCs include physiologic signs of inadequate oxygenation of the entire of a specific organ, hemoglobin concentration and logistic aspects such as experience of anesthesiologist and surgeons, predictability of blood loss and time required for a hemoglobin determination and RBS delivery[8,15]. Defining transfusion triggers for red blood cell transfusions is important to avoid unnecessary RBC transfusions and equally to avoid under transfusion in situations where RBC transfusions may be beneficial[6].

The American College of Physicians recommended that RBC transfusions should be done unit by unit and the patient should be evaluated between each transfusion[7].

Tartter Pl and Barron DM in their study of patients undergoing curative surgery for colo-rectal malignancies concluded that excessive intraoperative transfusion and the practice of administering blood without reevaluating the hematocrit in between resulted in 90% of the unnecessary transfusions. They further recommended that the determination of the hematocrit immediately before administration of each unit would reduce blood consumption by 25%[8].

Spahn DR and Casutt M in their study suggested that the minimal hemoglobin level tolerated without organ dysfunction is referred to as the Critical Hemoglobin.[9,16,17] In the early post-anesthetic period, patients are most vulnerable to adverse events due to perioperative anemia. Anesthesiologist should transfuse RBCs focusing on the postoperative Target Hemoglobin. Unfortunately akin to the "Transfusion Triggers", this "Target Critical Hemoglobin" is ill defined and often controversial.

Paloma Toledo et al in their study reported that the blood spilled onto the floor was underestimated by 35%-50% by both the anesthesiologist and the other obstetric team.

Error in estimating blood loss is dependent on actual blood loss volume. Blood loss tends to be over estimated at low volume loss and underestimated at high volume loss in the study conducted by Gart A et al. Perioperative transfusion practices and its implication on morbidity and mortality have depended on the accuracy of clinically estimated blood loss. [18,19,20] Though these clinical methods are simple to perform and can be performed repeatedly at no additional cost or complication to the patient, they may largely depend on the anesthesiologists experience and expertise in estimating blood loss. Since the above constellation of factors are dynamic and evolving and in a sense "real time", anesthesiologists should repeatedly estimate the blood loss. These clinical estimations and changes in the monitored hemodynamic variables should be interpreted by the anesthesiologists and used to determine the time of testing the hematocrit. RBC transfusions should be indicated only by the change in hematocrit. These tests can now be easily and economically be performed in the operating rooms itself and repeated as often as indicated preferably before and after each transfusion of RBCs[21]. From this study we conclude that the practice of perioperative blood transfusion is a balancing act between clinical benefits and the adverse transfusion outcomes where we have to rely on definite laboratory values or point of care estimations of Hematocrit and on clinical estimation of blood loss alone.

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