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Assessment of accuracy of clinical blood loss estimation compared to actual blood loss during major surgeries

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ABSTRACT

Objectives: This study aims to assess the accuracy of clinical blood loss estimation compared to actual blood loss (ABL) during major surgeries.

Materials and Methods: Fifty patients undergoing major surgery for various indications were included in the study. They were assigned into two groups of 25 each as they came, Group C (clinical method group) and Group F (formula method). In Group C, blood loss estimation was carried out using the clinical method of blood loss estimation (gravimetric and visual methods) whereas, in Group F, the blood loss was obtained using the modified gross formula method. The data obtained from the study were analyzed electronically using the Statistical Package for the Social Sciences version 20.0 and these data were presented using relevant tables and figures. A comparison of blood loss between the two groups was determined using an unpaired Student *t*-test.

Results: The mean hematocrit (HCT) before the surgery was 34.00 ± 0.52, whereas the mean HCT after the surgery was 29.00 ± 0.61. The mean drop in HCT was 5.00 ± 0.36. The mean ABL was 855.80 ± 83.17 mL. The mean blood loss estimated by the gravimetric method was 805.40 ± 392.72 mL, whereas the mean error of estimation by the gravimetric method was 50.40 ± 163.23 mL which was statistically not significant ($P = 0.30$). The mean blood loss by visual method was 650 mL ± 132.34. The mean difference between ABL and visual method of estimation was 205.60 mL, and this was statistically significant ($P = 0.02$).

Conclusion: The gravimetric method and visual method of blood loss were the two clinical methods of blood loss estimation used in this study. The two clinical methods when compared to ABL, they underestimated the blood loss by 19.24% and 39.48%, respectively.

Keywords: Accuracy, Clinical blood loss estimation, Actual blood loss, Major surgeries

INTRODUCTION

Intraoperative blood loss estimation is an integral part of major surgery. Major surgeries are associated with significant blood loss and this can increase morbidity and mortality. It can be defined as any invasive procedure in which more extensive resection is performed, for example, the body cavity is entered, organs are removed, or normal anatomy is altered.[1] These surgeries are associated with expected blood loss of more than 1000 mL and significant fluid shift, thereby causing acute anemia and it can affect the healing of tissues.[1]

Despite improvements in surgical technique, such as the use of tourniquets, local infiltration with lidocaine/adrenaline, and hypotensive anesthesia, major surgeries are associated with significant blood loss.[2] Acute blood loss may cause shock which may lead to reduced oxygen delivery and tissue perfusion, cellular hypoxia, organ damage, and the common cause of death during surgery.[3]

Several studies have shown inaccuracy associated with clinical estimation of blood loss compared to calculated actual blood loss (ABL).[4-6] These inaccuracies result in overestimation and underestimation of blood loss and its complications.

The underestimation of blood loss may result in inadequate fluid resuscitation, hypovolemia, shock, organ damage, myocardial infarction, and impaired tissue oxygenation.[7]

On the other hand, overestimation of blood loss could lead to blood transfusion which exposes patients to unnecessary risks and complications such as immune-mediated reactions, transmitted infections, transfusion-related acute lung injury, and transfusion-related circulatory overload.

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These methods of blood loss estimation are simple, cheap, devoid of complications, and can be practiced even in remote places.

MATERIALS AND METHODS

This is a prospective observational study for patients scheduled for elective major surgeries in our Teaching Hospital. The study was conducted from May 2018 to November 2018 after approval from the Ethics and Research Committee of our Hospital UDUTH/HREC/2018/No. 661.

After written informed consent, 50 patients with the American Society of Anesthesiologists (ASA) physical status I and II, between the ages of 18 and 60 years, scheduled to undergo elective major surgeries under regional anesthesia were included in the study.

Any patient who refused the procedure, patient with a history of drug allergy, infection at the site of the block, coagulopathy, a patient on anticoagulants and distorted anatomy of the foot or spine, and a patient with compromised vascular supply to the foot were excluded from the procedure. The patients who do not consent to the procedure, patients with severe anemia with hematocrit (HCT) <21%, patients receiving anticoagulants or antiplatelet, patients with bleeding, coagulation, or hematological disorders, and patients who require a blood transfusion due to massive blood loss were excluded from the study.

The sample size was determined using figures and formulae from a similar study by Bose *et al*.[8] and based on an effect size formula for sample size calculation.[9]

The minimum sample size per group equals to 24. However, 25 patients were recruited from each group making a total number of 50 patients in the study.

The anesthetic technique was administered by the consultant's anesthetist and senior registrars using standard anesthetic management for the procedure and all the patients received standard ASA monitoring using a multiparameter monitor (GE Dash 4000 KOMED, Laguna Niguel, USA) to record pulse oximetry (CAS M. California, USA), non-invasive blood pressure, (electrocardiogram, lead III and V2), temperature, and urine output. The surgeries were also carried out by either the consultants or the senior registrar using the same surgical technique.

These 50 patients undergoing major surgery for various indications were assigned into two groups of 25 each as they come; Group C (clinical method group) and Group F (formula method). In Group C, blood loss estimation was carried out using the clinical method of blood loss estimation (gravimetric and visual methods), whereas, in Group F, the blood loss was obtained using the modified gross formula method.

The numbers of mops and gauzes used during the surgeries were noted by either the researcher or any of the trained assistants. The volume of blood in the suction machine canister was recorded. After the surgery, each mop used was weighed and subtracted from the predetermined weight of the mop to determine the blood loss. Every 1 g of gauze was equivalent to 1 mL.[10] This was added to the volume of blood from the suction machine canister to make up the gravimetric method of estimation of blood loss. When abdominal drain is used, the volume is determined and added to the intraoperative volume of blood loss.

The lead surgeon documented the visual estimation and recorded it in the operation notes without the knowledge of the blood loss estimated by the gravimetric method.

Clinical intraoperative blood loss estimation was commenced using the following methods: volumetric method, gravimetric method, and visual method.

Guidelines for these estimations are as follows: Each fully soaked 10.6 cm (4 inches) by 10.6 cm surgical sponge's holds approximately 10 mL of blood and each fully soaked 30.48 cm (12 inches) by 30.48 cm gauze laparotomy tape hold approximately 100–150 mL of blood. If the items are partially saturated, the anesthetist must approximate how much blood the items contained.[11]

In the volumetric method, the volume of the suction canister at the end of the surgery was measured and the volume of irrigation fluid was then subtracted from the total volume of the canister.

While in the gravimetric method, the dried weight of standard surgical swabs and abdominal pack was subtracted from their soaked weight using a standard weighing apparatus in grams and these values in grams were converted to mL according to Rain's factor, 1 g of gauze equals to 1 mL of blood. The standard measurement of the surgical swab is 10.6 cm (4 inches) by 10.6 cm and the standard abdominal pack is 30.48 cm (12 inches) by 30.48 cm. The amount of blood lost to surgical instruments, drapes, scrubs, gowns, operative field, and floor was visually estimated.

The total volume of volumetric measurements, gravimetric measurements, and visual estimations was added to give the total volume of intraoperative blood loss using clinical estimation.

Following 24 h after the surgery, patients were visited in the ward, and blood samples were obtained for post-operative final HCT check (Hct_f).

ABL of each patient was then calculated using the modified gross formula as shown below.[12]

ABL=BV (Hcti–Hctf)/Hctm

Where;
ABL = Actual blood loss
BV = Blood volume based on body weight
Hcti = Initial hematocrit (pre-operative hematocrit)

Hctf = Final hematocrit (post-operative hematocrit)
Hctm = Mean hematocrit.

Statistical analysis

An interviewer–administered structured questionnaire was used in data collection and these data were analyzed electronically using the Statistical Package of the Social Sciences version 21. The results obtained were expressed as mean ± standard deviation except where stated otherwise. The paired Student *t*-test was used to compare the mean blood loss estimation by the (clinical method) gravimetric and actual estimation: between the visual method and ABL. The correlation between gravimetric method and actual method, visual method, and actual method was done using Pearson's correlation coefficient.

RESULTS

A total of 50 patients participated in this study. The mean age of the subjects was 37.34 ± 9.35. The modal age group was 40–49, which accounted for 27/78 (34.60) of the subjects. The sociodemographic parameters are shown in Table 1 and the differences were not statistically significant.

The mean HCT before and after the surgery is shown in Table 2. The mean ABL, the mean blood loss estimated by clinical method (gravimetric and visual methods), and the mean error of estimation by these methods are shown in Table 2.

The mean difference between the estimated ABL and the blood loss estimated by the gravimetric method was 50.40 mL. This was not statistically significant. The mean difference between ABL using the formula method and blood loss by visual estimation was 205.60 mL. There was a statistically significant difference between the ABL and blood loss by visual method (*P* = 0.02).

The gravimetric method and visual method of blood loss were the two clinical methods of blood loss estimation used in this study. The two clinical methods when compared to ABL, they underestimated the blood loss by 19.24% and 39.48%, respectively.

DISCUSSION

The study evaluated the accuracy of the (clinical) gravimetric method of blood loss estimation by comparing it to the ABL method (formula method) of blood loss estimation. The actual mean blood loss (formula method) was 855.80 mL. The mean HCT pre-procedure was 34 ± 0.39, whereas it was 29.00 ± 0.40 post-procedure. The mean difference in HCT was 5.00 ± 0.38. The mean difference between the estimated ABL (formula method) and the blood loss estimated by the (clinical method) gravimetric method was 50.40 mL. This was not statistically significant (*P* = 0.30). The mean blood loss by visual method is 650.20 mL. The mean difference between ABL and visual method is 205.60 mL. There was a statistically significant difference between the ABL and blood loss by visual method (*P* = 0.02).

The mean difference between the estimation by (clinical method) gravimetric method and the ABL estimate was not statistically significant. There was also a strong correlation between the two methods of estimation. This implies that the gravimetric method is a reliable method of blood loss estimation because the differences between the ABL (formula method) and the clinical (gravimetric method) of blood loss estimation are not much. This is similar to observations observed by several authors.[4,13,14]

Bose *et al*.,[8] in a prospective study, determined the accuracy of the clinically estimated blood loss. The ABL was calculated based on a modification of Gross's formula using hematocrit values. The differences between the two means were found to be around 205 mL which was statistically significant. The study showed that using clinical estimation alone to guide blood transfusion is inadequate.

In another study, Abbasi *et al*.[15] compared visual estimation of blood loss with serial hemoglobin and hematocrit estimation in supratentorial craniotomy. Fifty-six patients were recruited for the study. In 24% of cases, the estimation of hemoglobin fell within the accurate range, whereas 62% of cases overestimated hemoglobin, and 14% of cases underestimation was observed. They concluded that the estimated blood loss is not a good predictor of the calculated blood loss. The laboratory investigation was found to have significant differences with the routine method of visual estimation of blood loss during supratentorial craniotomy. The limitation of this study was unavoidable because these estimations were done by four anesthetists involved in neurosurgical anesthesia. Therefore, interobserver variability and bias cannot be eliminated.

Table 1: Demographic and ASA values of Group C and Group F.

	Group C (*n*=25) Mean(±SD)	Group F (*n*=25) Mean(±SD)	*P*-value
Age (years)	38.52 (±11.66)	35.96 (±10.83)	0.425
Sex (M, F)	14 (60.9%), 9 (39.1%)	16 (64%), 9 (36%)	0.564
Weight (Kg)	65.56 (±8.07)	63.96 (±9.92)	0.535
ASA Status I/II	13 (56.5%), 10 (43.5%)	17 (68%), 8 (32%)	0.382

P≤0.5, the difference is statistically significant, SD: Standard deviation, ASA: American Society of Anesthesiologists

Table 2: Summary of the mean and differences of estimation.

Parameter	Mean standard deviation
Actual Blood loss	855.80 (63.17)
Blood loss estimation by gravimetric	805.40 (492.72)
Blood loss estimation by visual estimation	650.20 (440.91)
The error of estimation by gravimetric method	50.40 (263.23)
The error of estimation by visual method	205.60 (608.53)
Pre-operative hematocrit	34.00
Post-operative hematocrit	29.00
Mean differences in hematocrit	5.0

Ashrat and Ramadani[16] studied 100 patients undergoing cesarean section. Each patient's blood loss was assessed by three methods: Subjectively by the attending staff (anesthetist, obstetrician, and scrub nurse) by weighing surgical soaked gauzes and by calculation using the formula by Bourke and Smith. They concluded that the intraoperative blood loss during cesarean section was overestimated by the formula used and was underestimated visually by the obstetrician and the scrub nurses involved. Reliably, the anesthetist gave the closest estimation to that obtained by the gravimetric method.

In contrast, Johar and Smith[17] found no significant correlation between the blood loss estimated by the gravimetric method and blood loss as measured by the same laboratory method. The difference could be due to the study design and standardization of study instruments.

Again, Manikandan *et al*.[18] studied 50 patients undergoing adenotonsillectomy to compare intraoperative blood loss between the two methods of measurements. The gravimetric method and calculated ABL method using blood volume were used to measure intraoperative blood loss. The estimated intraoperative blood loss by gravimetric method was 94.35 mL, whereas the actual intraoperative blood loss by blood volume method was 90.57 mL and the average intraoperative blood loss was 92.46 mL. This study concluded that the differences between the clinical method by gravimetry and the ABL by blood volume are not statistically significant. Although, the overall total intraoperative blood loss in adenotonsillectomy is not much.

This observation agrees with the findings that visual estimation of blood loss was inaccurate and as such unreliable in the estimation of blood loss during surgery.[19-21]

The strength of this study was the blood loss estimation using the gravimetric method was done in real time during the surgical procedures. Thus, its use during the procedure will provide the surgical and anesthetic teams with information that can be used in conjunction with monitoring of vital signs to determine the threshold for giving patients blood products.

Strengths and limitations of the study

The strength of this study is that it was a real-time estimation and involved the use of standardized instruments in addition to reproducibility. The major limitation is that it may not be replicated with the use of non-standardized instruments, and again it is a single-center study. Therefore, a multicenter study is needed to substantiate the findings of this study. Moreover, studies with a large number of sample size are needed to substantiate the findings of our study.

CONCLUSION

The clinical method (gravimetric method) of blood loss estimation compared favorably with ABL estimation. It can be used in the estimation of blood loss during major surgeries. This will aid in prompt intervention in the management of intraoperative bleeding. The visual method of blood loss estimation is not a reliable method of blood loss estimation when compared to ABL.

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Ethical approval

The research/study approved by the Institutional Review Board at Usmanu Danfodiyo University Teaching Hospital, Sokoto. Nigeria., number UDUTH/HREC/2018, dated 2018.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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