Original Article

Evaluation of the HemoCue® for blood loss estimation in suction fluid in patients undergoing neurosurgical procedures: A prospective observational study

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Abstract

Background and Aims: Blood loss in neurosurgical procedures can be rapid and tremendous leading to consequential hemodynamic instability. HemoCue is a portable photometer used for the measurement of blood hemoglobin concentration. Using this point of care device, we contemplated this study to assess the reliability of HemoCue for suction hemoglobin determination and calculation of surgical blood loss by comparing with the gold standard laboratory Coulter Counter method in patients undergoing neurosurgical procedures.

Material and Methods: This prospective observational study was conducted in 233 patients undergoing elective neurosurgical procedures in the age group of 18 to 60 years and having preoperative hemoglobin (Hb) values above 9 g/dL. Values of preoperative hemoglobin, suction hemoglobin, and volume in the suction container were used to obtain the estimated blood loss. The normality of the data was tested using the Kolmogorov Smirnov test. Bland Altman analysis was used to test the reliability of HemoCue in estimating hemoglobin and blood loss with reference to the gold standard laboratory Coulter Counter automated hematology analyzer.

Results: Median blood loss calculated in our study using HemoCue was 554.65 mL with an interquartile range of 336.81 mL to 982.39 mL. Laboratory counter method estimated median blood loss was 533.37 mL with an interquartile range of 335.21 mL to 994.73 mL. The majority of the data obtained and analyzed using the Bland and Altman analysis method were within a 95% confidence interval.

Conclusion: The HemoCue method is a reliable method and henceforth can be used to estimate blood loss in suction fluid in patients undergoing neurosurgical procedures.

Keywords: Blood loss, HemoCue, neurosurgical procedures, suction fluid

Introduction

Neurosurgical procedures can lead to sudden and relentless blood loss which is usually mixed with cerebrospinal fluid and normal saline used for irrigation. Blood transfusion remains the cornerstone of managing volume depletion during neurosurgeries and henceforth quick decisions made regarding perioperative blood transfusion have always proven beneficial.[1] Accurate and rapid blood loss estimations would prevent hazards of under transfusion of blood including reduced blood oxygen-carrying capacity, hypoperfusion, and organ ischemia.[2]

The biochemical principle used in HemoCue is oxidation in which hemoglobin is oxidized to methemoglobin by sodium

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nitrite. The absorbance in HemoCue photometry is measured at two wavelengths to compensate for turbidity present in the sample collected.[3] There are only a few studies to estimate blood loss in a suction fluid using HemoCue® which were conducted in cesarean sections, myomectomies, and transurethral resection of prostate (TURP) surgeries. In this study, we hypothesized that HemoCue device can be used to estimate surgical blood loss in suction fluid in neurosurgical procedures.

The primary objective of this study was to estimate the accuracy of HemoCue® device for blood loss estimation in the suction fluid using hemoglobin of suction fluid determined by HemoCue® device in comparison with laboratory Coulter Counter analysis method which is taken as the gold standard. The secondary objective was to determine the reliability of HemoCue in clinical decision-making regarding perioperative blood transfusion in the future if HemoCue proved to be reliable by this study.

Material and Methods

This study has institutional ethics committee approval bearing EC/33/2018.

This was a prospective observational study. Two hundred and thirty-three patients were recruited for this study. Patients undergoing elective neurosurgical procedures in the age group of 18 to 60 years and having preoperative hemoglobin value of ≥9 g/dL one day before surgery were included in this study. A written informed consent was obtained from the study subjects before surgery. Patients refusing to give informed written consent, patients with unsound minds, and patients with ongoing blood transfusion scheduled for neurosurgery were excluded from this study.

The standard protocol followed in our hospital for blood loss estimation is a visual assessment of blood loss in a suction bottle, surgical field, drapes, and mops by the anesthetist intraoperatively. The standard hospital protocol of visual method of blood loss estimation as mentioned above was continuously followed intraoperatively by the anesthetist and intraoperative blood transfusions were given accordingly. Estimation of hemoglobin concentration and blood loss in the suction bottle was done at the end of each neurosurgery using HemoCue and laboratory counter analysis.

Thorough preoperative evaluation along with baseline hematological and biochemical investigations were reviewed for every patient. Preoperative hemoglobin values were determined one day before surgery using the laboratory Counter method, and these values were documented in the case records. In the operating room, ASA standard monitors (electrocardiogram, pulse oximeter, and noninvasive blood pressure) were applied. All the patients received balanced general anesthesia. Invasive blood pressure monitoring was carried out by cannulating radial after induction. To prevent clotting of blood, 5 mL EDTA (10%) per 500 mL of the suction bottle was added before surgery. At the end of the procedure, the total volume in the suction container was recorded. The suction bottle was shaken to get a uniform sample, and 50 mL of this sample was filtered through a blood set of 40 microns filter size. Three mL of this filtered sample was sent to the laboratory for hemoglobin estimation which was recorded as laboratory suction hemoglobin concentration in g/dL. Hemoglobin concentration of this sample was also obtained using HemoCue®, and this value was recorded in the case record form as HemoCue® suction hemoglobin concentration in g/dL. Values of preoperative hemoglobin, suction hemoglobin, and volume in the suction container were substituted in the below-mentioned formula to obtain the estimated blood loss.

Blood loss in suction (mL) = volume in bottle (mL) × suction Hb concentration (g/dL) ÷ Preoperative hemoglobin concentration (g/dL). Values of blood loss were calculated using the above-mentioned formula by both HemoCue and laboratory Coulter Counter methods, and the values were recorded for analysis.

The data was compiled, collected, and entered in Microsoft excel. The data were analyzed using SPSS version 20.00. The qualitative data were expressed in terms of proportions. If the quantitative data was non-normal data, it was expressed in terms of either median or interquartile range. If the data were normal data, it was expressed in terms of mean and standard deviation. The normality of the data was tested using the Kolmogorov Smirnov test. Bland Altman analysis was used to test the reliability of HemoCue in estimating hemoglobin and blood loss with reference to the gold standard laboratory Coulter Counter automated hematology analyzer.

Sample size calculation was done by MedCalc Statistical Software version 17.9.7 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2017). Sample size calculation was based on the study conducted by Gupta A *et a*l. where they used HemoCue to estimate blood loss in cesaerean sections· 5 For α-level of 0.05 and β-level of 0.20 (power is 80%) with a mean difference in Hb by two methods of 0.038 mg/dL and standard deviation of 0.206. The minimum sample size obtained was 233.

Results

Demographic data: The mean age of the study subjects was 40.18 years, and the most common age group was

51 to 60 years followed by 31 to 40 years in the present study [Table 1]. About 54.51% were male and 45.49% were female in the present study [Table 2].

About 65.67% were intracranial surgeries which included excision of space-occupying lesions such as gliomas, meningiomas, ependymomas, pituitary macroadenomas, craniopharyngiomas, acoustic schwannomas, and aneurysmal clipping; 29.61% were spinal surgeries which included C1C2 lateral mass fixation for atlantoaxial dislocations (AAD), pott's spine instrumentation, and intradural extramedullary tumors excision; 4.72% were others which included excision of cerebellar hemangioblastoma and decompression for trigeminal neuralgia [Table 3]. Blood loss was maximum in surgeries for AAD and minimum in microvascular decompression for trigeminal neuralgias and pituitary macroadenoma excisions.

A total of 200 out of 233 patients in our study required intraoperative blood transfusion. The mean hemoglobin preoperatively was 12.92. About 45.06% had hemoglobin between 9 and 11, 38.63% had hemoglobin between 11 and 13, and 16.31% had more than 13 g/dL [Figure 1] [Table 4]. The median volume of blood in suction was 1000 mL with interquartile range of 700 to 1500. The majority of the subjects had volumes between 500 and 1000 mL in the present study [Figure 2] [Table 5]. The red line indicates the mean reference line of the data set (-0.06). The green line indicates the upper 95% confidence reference line (0.2536). The blue line indicates a lower 95% confidence reference line (-0.3736). The majority of the data were present between the two 95% confidence interval lines [Figure 3]. So, we can infer that HemoCue method is a reliable method to estimate suction hemoglobin concentration.

The red line indicates the mean reference line of the data set (-5.09). The green line indicates the upper 95% confidence reference line (30.484). The blue line indicates a lower 95% confidence reference line (-40.664). The majority of the data were present between the two 95% confidence interval lines [Figure 4]. So, we can infer that HemoCue is a reliable method to estimate the amount of blood loss.

Table 1: Distribution of the study subjects based on the age group

Age group	Frequency	Percentage
<20	19	8.15
21-30	52	22.32
31-40	49	21.03
41-50	48	20.60
51-60	65	27.90
Total	233	100
Mean	40.18	
SD	13.21	
Range	18 to 60	

Table 2: Distribution of the study subjects based on the gender

Gender	Frequency	Percentage
Female	106	45.49
Male	127	54.51
Total	233	100.00

Table 3: Distribution of the study subjects based on the type of surgeries

Type of surgeries	Frequency	Percentage
Spinal surgeries	69	29.61
Intra cranial surgeries	153	65.67
Others	11	4.72
Total	233	100.00

Table 4: Comparison of hemoglobin values obtained by laboratory Coulter Counter and HemoCue methods

Suction hemoglobin	Mean (g/dL)	SD (g/dL)	Range (g/dL)
Laboratory value	7.21	1.89	3.3-13.90
HemoCue value	7.27	1.88	3.3-14.10

Table 5: Comparison of blood loss between laboratory Coulter Counter and HemoCue methods

Blood loss	Median (mL)	Interquartile range (mL)
Coulter Counter	533.37	335.21-994.73
HemoCue	554.65	336.81-982.39

Discussion

In this prospective observational study, we evaluated the HemoCue device for blood loss estimation in 233 patients undergoing elective neurosurgical procedures. We chose this class of patients undergoing neurosurgical procedures as these procedures are associated with massive surgical hemorrhage which leads to sudden hemodynamic compromise which would result in a reduction in cerebral perfusion and cerebral hypoxia worsening the neurological outcome. In our study, mean suction hemoglobin concentration by laboratory method was 7.21 g/dL, and by HemoCue method was 7.27 g/dL. The range of suction fluid hemoglobin by laboratory method was 3.3 g/dL to 13.9 g/dL, and by HemoCue method was 3.3 g/dL to 14.1 g/dL. Standard deviations by laboratory and HemoCue methods were 1.89 g/dL and 1.88 g/dL, respectively. Bland Altman analysis of hemoglobin values in our study showed that the majority of data plotted were within 95% confidence intervals. Bias and limits of agreement were -0.01 and -0.37 to 0.25 which were similar to the

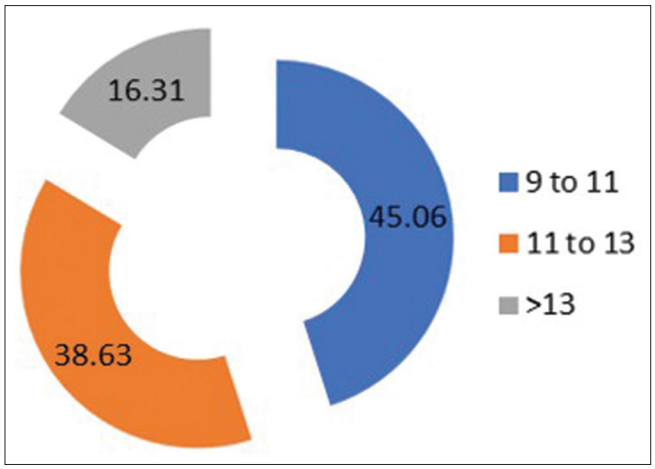

Figure 1: Distribution of the study subjects based on the pre-operative hemoglobin

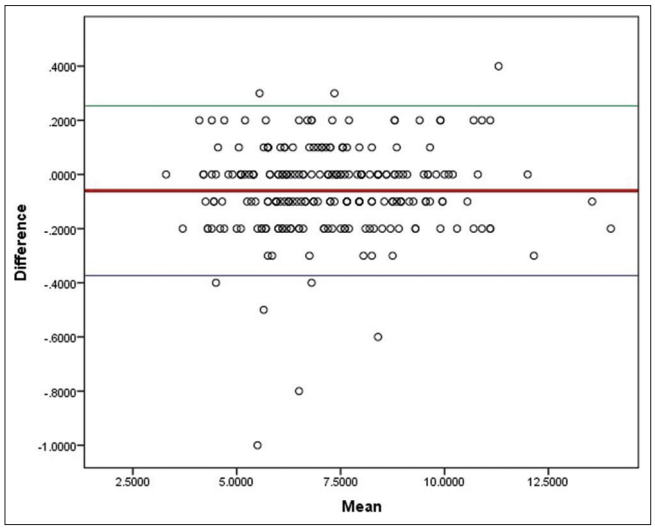

Figure 3: Bland Altman analysis of the suction hemoglobin concentrations determined by HemoCue method in comparison with the laboratory method

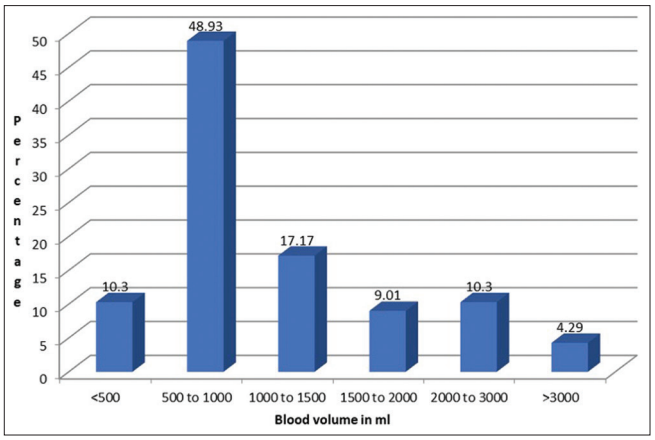

Figure 2: Distribution of the study subjects based on the blood volume in suction

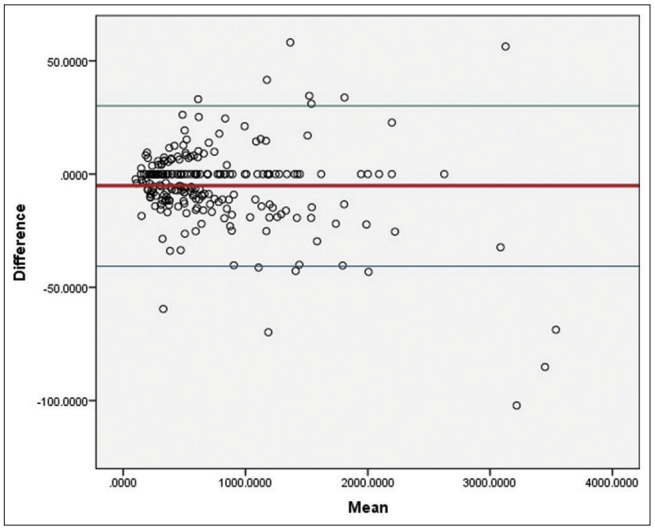

Figure 4: Bland Altman analysis of the blood loss estimated by HemoCue method in comparison with laboratory estimation

study conducted by Gupta *et al.*[5] who used HemoCue for blood loss estimation in patients undergoing elective cesarean section in which the bias and limits of agreement were 0.013 and -0.39 to 0.36.

Anemia-induced cognitive dysfunction is evident at hemoglobin (Hb) concentrations between 5.0 and 6.0 g/dL.[4] Hence, the adoption of a meticulous blood loss estimation method and prompt transfusion strategies are of paramount importance to improve short-term as well as long-term outcomes of patients undergoing neurosurgical procedures. Suction fluid hemoglobin concentrations measured during the perioperative period and deriving the estimate of blood loss during the surgery from the value of hemoglobin concentration obtained can provide a near precise and quick estimate of surgical hemorrhage. Suction hemoglobin measurements can be done using HemoCue, laboratory Coulter counter automated analyzer, and cyanmethemoglobin methods. The cyanmethemoglobin method is used when automated analyzers are not available. This method though cheaper, takes more time. The HemoCue Hb 301(Angelholm, Sweden) is a small portable device well designed to measure the concentration of hemoglobin.[5] Approximately, 10 μL of blood is sucked into the microcuvette. The entire chemical process is completed within 45 s, and the concentration of hemoglobin is displayed on the display bar or screen present on this device proving it to be quicker than the other methods of hemoglobin estimation. It has also been demonstrated to be very accurate through the clinical range down to 2.5 g/dL.[6,7]

In a study conducted by Oshima M *et al.*[8] to estimate blood loss in patients undergoing laparoscopic myomectomy using HemoCue device, the range of suction fluid hemoglobin

values measured by HemoCue was 0.2 to 4.7 g/dL. Another study conducted by Lamhaut *et al.*;[9] did a comparison between hemoglobin values measured by HemoCue method with that of a laboratory automated analyzer. The bias of HemoCue method was -0.17 ± 1.05 g/dL with a precision of 0.67 ± 0.83 g/dL. The difference between the two methods was ± 1 g/dL which was acceptable.

In the study conducted by A. Gupta *et al.*;[5] the median blood loss calculated by HemoCue was 768 mL with a standard deviation of 496 mL.7 Bland and Altman plot showed 95% agreement limits. In the study conducted by Ekengren J *et al.*[10] to estimate blood loss in patients undergoing transurethral resection of the prostate, the median calculated blood loss by HemoCue was 300 mL with a range of 10 mL to 3825 mL. In our study, the majority of the data of blood loss obtained and analyzed using the Bland and Altman analysis method were within 95% confidence interval. So, we can infer that the HemoCue method is a reliable method of blood loss estimation.

Limitations

The study group included in our study are patients undergoing elective neurosurgical procedures. Hence, results cannot be extrapolated for emergency procedures. Baseline Hb was estimated only by the lab method. HemoCue method should have been done simultaneously to see the agreement between the two methods for the baseline. HemoCue method of hemoglobin and blood loss estimation described requires scrupulous sampling of blood from the suction bottle as described, failure of which leads to erroneous readings. To calculate the blood loss during surgery, both pre-operative and post-operative -Hb are necessary. Here, post-operative Hb estimation was not done. Without post-operative Hb value, it is not possible to comment on the blood volume lost during surgery. Blood volume was not calculated.

Also, this method cannot be used solely for blood loss estimation. Always requires supplementation by visual or gravimetric methods for blood collected in surgical field and drapes. Further studies are required to establish its efficacy for blood loss estimation over other methods.

Conclusion

The HemoCue®device can be used for blood loss estimation collected in the suction bottle in patients undergoing elective neurosurgical procedures. Also, the HemoCue technique for point of care estimation of hemoglobin and blood loss is quicker and requires a small sample of blood.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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