COMPARISON OF VISUAL ESTIMATION OF INTRAOPERATIVE BLOOD LOSS WITH HAEMOGLOBIN ESTIMATION IN PATIENTS UNDERGOING CAESAREAN SECTION AT TERM.

A dissertation submitted to the National Postgraduate Medical College of Nigeria in part fulfillment of the requirements for fellowship of the College in Anaesthesia.

BY

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NOVEMBER 2015
DECLARATION

I hereby declared that this work is original. The work has not been presented to any other college for fellowship nor has it been submitted elsewhere for publication.

Dr Anya Sampson U
NOVEMBER 2015
CERTIFICATION

The dissertation contained in this document was prepared by the author under our supervision. We have supervised the study and the writing of the dissertation.

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DEDICATION

This dissertation is dedicated to all obstetric patients who have undergone elective caesarean section under spinal anaesthesia.
ACKNOWLEDGEMENT

I am indebted to several people who at various stages in my career have contributed towards the success of my professional training. I would like to recognize the impact of my consultants beginning with Dr S. Abubakar and Dr M. Yusuf who laid the foundation for my training in anaesthesia, and also the special role played by Dr V.O. Ajuzieogu, Dr H.A. Ezike, Dr F.A. Onyekwulu, Dr T. Onyeka, Dr A. Amucheazu, Dr M.O. Nwoke and Dr P. Ufoegbunam, in building my career. My special thanks to Dr E.C. Onuora who specifically helped me in deciding on this topic and Dr E.I. Obi, of Community Medicine who assisted me with relevant statistics.

I will also like to recognize all colleagues in my department and the theatre staff who gave me full cooperation in the course of the study and also colleagues in the department of Obstetrics and Gynaecology who were very helpful to me by keeping me abreast of all their booked elective caesarean sections. My special thanks to the manufacturers of HemoCue for providing a local distributor in Nigeria thereby making the device easily accessible.

I am highly indebted to my wife and children, Uchechi, Ngozichukwu and Godwin who have always been very supportive. My sincere gratitude goes to my wife for her patience and ever-loving ways with me who sometimes had to stay up late in the night to keep me company while working on this project. She is absolutely the greatest!
### LIST OF ABBREVIATIONS

<table>
<thead>
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<th>Abbreviation</th>
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<tbody>
<tr>
<td>AAGBI</td>
<td>Association of Anaesthetists of Great Britain and Ireland</td>
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<td>ABL</td>
<td>Actual blood loss</td>
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<td>ASA</td>
<td>American Society of Anesthesiologists</td>
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<td>AVG-BL</td>
<td>Average blood loss</td>
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<td>BV</td>
<td>Blood volume</td>
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<tr>
<td>CBL</td>
<td>Calculated blood loss</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence Interval</td>
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<tr>
<td>DIFF-BL</td>
<td>Difference in blood loss</td>
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<tr>
<td>EBL</td>
<td>Estimated blood loss</td>
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<td>G</td>
<td>Gauge</td>
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<td>gm</td>
<td>gram</td>
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<tr>
<td>Hb</td>
<td>haemoglobin</td>
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<tr>
<td>Hct</td>
<td>haematocrit</td>
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<tr>
<td>HIV</td>
<td>human immuno-deficiency virus</td>
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<tr>
<td>HR</td>
<td>heart rate</td>
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<td>hr</td>
<td>hour</td>
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<tr>
<td>ICSH</td>
<td>International Council of Standardization in Hematology</td>
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<tr>
<td>IU</td>
<td>International Unit</td>
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<tr>
<td>IV</td>
<td>Intravenous Fluid</td>
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<tr>
<td>kg</td>
<td>kilogram</td>
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<tr>
<td>Lab</td>
<td>Laboratory</td>
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<td>L</td>
<td>Litre</td>
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<td>Abbreviation</td>
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<tr>
<td>MDG</td>
<td>Millennium Development Goal</td>
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<tr>
<td>min</td>
<td>minute</td>
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<tr>
<td>ml</td>
<td>millilitre</td>
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<tr>
<td>NIBP</td>
<td>non-invasive blood pressure</td>
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<tr>
<td>p-value</td>
<td>probability value</td>
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<tr>
<td>SD</td>
<td>standard deviation</td>
</tr>
<tr>
<td>SpO₂</td>
<td>peripheral capillary oxygen saturation</td>
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SUMMARY

Background
Accurate assessment of intra-operative blood loss is an important aspect of peri-operative management of patients undergoing caesarean section and visual estimation is the most commonly used method and sometimes the only method available. Therefore, assessing the accuracy of visual estimation of blood loss compared to estimation using a point-of-care device such as the HemoCue is very relevant.

Aim and Objectives;
This study compared intraoperative blood loss by visual estimation with blood loss calculated from haemoglobin (Hb) estimation using the HemoCue®201+ (AB Medical Inc Sweden).

Patients and Method;
This was a prospective, double blind, non randomized, controlled comparative study in which each patient acted as her own control. Sixty ASA physical status I or II pregnant patients at term undergoing elective caesarean section under spinal anaesthesia were enrolled into the study. In the theatre, the patients’ Hb level was determined using the Hemocue prior to preloading with 10ml/kg of normal saline. Spinal anaesthesia was induced in the sitting position with 2.5ml of 0.5% hyperbaric bupivacaine. Intraoperatively, standard monitoring (Heart Rate, Blood Pressure, Respiratory Rate, Electrocardiograph, peripheral oxygen saturation and temperature) was observed and recorded for each patient. At the end of skin closure, the Hb level was measured using the HemoCue and blood loss was visually estimated and documented. A modified Gross formula was used to calculate the blood loss. Blood loss was visually estimated by the researcher (anaesthetist) and then compared with the measured blood loss using HemoCue.
**Result;**
A total of sixty patients participated in this study. The mean visual estimated blood loss and HemoCue calculated blood loss were 470 ± 221ml and 563 ± 204ml respectively with p-value =0.125 (paired t-test). There was a positive correlation between both methods (r = 0.66, n = 60, p = 0.002) using Pearson’s correlation. Agreement, according to Bland and Altman, indicated that the mean difference (bias) between both methods was +45ml and discrepancy between the two methods widens when blood loss is more than 500ml.

**Conclusion;**
This study showed that visual estimation of intraoperative blood loss by the anaesthetist did not differ significantly from Hemocue calculated blood loss during caesarean section. Visual estimation of blood loss by the anaesthetist is reliable and a useful skill especially in resource poor setting.
CHAPTER ONE

INTRODUCTION

Over the years, different methods have been used for the estimation of intraoperative blood loss which is an important aspect of peri-operative management of the surgical patient. Visual estimation has been the most commonly used method and sometimes the only method available for assessing intraoperative blood loss simply because it is easy, quick and convenient.

Accurate assessment of intra-operative blood loss is an important aspect of peri-operative management of patients undergoing caesarean section where blood loss is often dispersed and mixed with liquor.1 Anaesthetists in developing countries may not have the luxury of point-of-care monitoring devices and may have to rely on visually estimated blood loss and other clinical acumen in making this decision.2 An important step when reviewing transfusion practice is to see whether accurate assessment of blood loss is being done.3

Several studies within sub Saharan Africa using visual estimations of blood loss in suction bottles, blood mixed with liquor in and around the operating field, counting of soaked abdominal packs and gauze reveal a high transfusion rate of up to 25.2% among women undergoing caesarean section and appreciable numbers were unnecessary transfusion.4-6 Inaccurate blood loss estimation can lead to either over or under transfusion. Blood transfusion may be associated with adverse immunological transfusion reactions, transmission of infections, increased cost, increased peri-operative morbidity and mortality and delayed recovery from anaesthesia.7,8,9
Accurate blood loss assessment minimizes the frequency of under or over transfusion of surgical patients. Major haemorrhage, if left unattended to, continues to be one of the most common causes of direct maternal death in obstetric practice. The anaesthetist has a role to play in the prevention and reduction of maternal mortality associated with intraoperative blood loss during caesarean section as advocated in the United Nation’s Millennium Development Goals (MDG).

The HemoCue is a useful medical device that can accurately determine a patient’s haemoglobin level and therefore can be utilized for direct measurement of blood loss. The Confidential Enquiries into Maternal and Child Health of Great Britain recommends the perioperative use of HemoCue in aiding the management of maternal haemorrhage. Therefore, assessing the accuracy of visual estimation of blood loss compared to estimation using a point-of-care device like the HemoCue will be very relevant in optimal obstetric care.
AIM/OBJECTIVES

AIM

To compare intraoperative blood loss by visual estimation with blood loss calculated from haemoglobin estimation using the HemoCue.

SPECIFIC OBJECTIVES

1. To determine the average blood loss from caesarean section using visual estimation.
2. To determine the average blood loss from caesarean section by haemoglobin estimation using the HemoCue test.
3. To compare blood loss assessment using visual estimation and the HemoCue test.
JUSTIFICATION FOR THE STUDY

Visual estimation often leads to over or under-estimation of blood loss, and it becomes even more inaccurate when large amount of blood loss is involved or the blood gets mixed with other fluids. The objective methods of estimation of intra-operative blood loss include but not limited to gravimetric measurement, haemoglobin colorimetry, electrical conductance and osmolality. These have all failed to gain wide acceptance due to their various limitations of being time consuming, expensive and impractical. Visual estimation remains the commonest method of assessing intraoperative blood loss in most operating rooms despite several studies suggesting that it is inaccurate.

In the University of Nigeria Teaching Hospital (UNTH) Enugu, anaesthetists often rely on visual estimation of blood loss alone to guide the transfusion of red blood cells in the perioperative period and this method of estimating blood loss has been frequently reported to be inaccurate and suffers from large inter observer variability and poor repeatability.

The HemoCue Haemoglobin estimation is a point-of-care testing which is relatively cheap and faster than the laboratory testing, with result readily available within 30-45 seconds. Also, comparing visually estimated intraoperative blood loss with this direct method of haemoglobin measurement will help to assess the level of accuracy of this method which is often being employed. The test can be easily learnt even by less skilled health care provider and will prove useful in rural areas.
This study is therefore set to investigate the accuracy of visual estimation of intraoperative blood loss when compared to haemoglobin estimation using the HemoCue during caesarean section
CHAPTER TWO

LITERATURE REVIEW

Maternal haemorrhage is the world’s leading cause of maternal mortality and accounts for an estimated 127,000 deaths per year with most of the deaths occurring in sub Saharan Africa. In 1987, The Safe Motherhood Initiative was launched in Nairobi Kenya with the goal of halving maternal mortality by the year 2000. Over two decades later, estimates in maternal mortality rates in sub Saharan Africa has shown no remarkable improvement as seen in a study conducted in six West African countries (Burkina Faso, Ivory Coast, Mali, Mauritania, Niger and Senegal) where an estimate of maternal mortality rate of 1,020 maternal deaths per 100,000 live births was documented. Also a similar study conducted in Northern Nigeria in 2011 revealed a maternal mortality rate of 1,271 deaths per 100,000 live births and in both studies maternal haemorrhage was the leading cause of deaths. However, the latest trend in maternal mortality rate published in 2014 by Maternal Mortality Estimation Inter-Agency Group (MMEIG) revealed a significant progress in reduction of maternal deaths with maternal mortality rate of 560 per 100,000 live births across Nigeria.

Accurate intraoperative assessment of blood loss during caesarean section is crucial in reducing maternal mortality rate as advocated in the United Nation’s Millennium Development Goals (MDG). Delivery by caesarean section is by far the most commonly performed obstetric operation all over the world. Different figures varying from less than 500ml to more than 1000ml have been quoted as estimated blood loss during caesarean section.

Many factors have been implicated in intraoperative blood loss during caesarean section e.g previous scar, multiple gestation, polyhydramnios, placenta separation technique (manual
separation), placenta position (placenta praevia), skill of the obstetrician, type of anaesthesia (general anaesthesia), lack of use of oxytocic drugs and toxaemia of pregnancy.\textsuperscript{24-26}

Duthie et al.\textsuperscript{26} in their study used alkaline haematin method to measure blood loss in forty women with singleton pregnancies undergoing lower segment caesarean section and general anaesthesia. The mean measured blood loss was found to be 487 ml (range 164 – 1438ml) and was estimated by the observer with reasonable accuracy. They found the observer error in estimating blood loss higher if measured loss exceeded 600ml.

In another study done to determine the mean estimated blood loss during elective caesarean section, the anaesthetist and the obstetrician recorded a mean estimated blood loss of 498 ±176 ml and 592 ±222 ml respectively.\textsuperscript{27} This result was similar to that obtained by Duthie et al.\textsuperscript{26}

Physiological adaptation of the cardiovascular system in pregnancy results in 48% increase in plasma volume from 2600ml to 3850ml, relatively exceeding that of the 17% increase in red cell mass from 1400ml to 1640ml.\textsuperscript{28} The protective haemodilution initiates a fall in haemoglobin, haematocrit and red cell count but maintains mean corpuscular haemoglobin concentration.\textsuperscript{29} Circulating blood volume rises by 37% from approximately 4000ml to 5500ml, providing not only adequate placental perfusion but also a compensatory reserve.

Visual estimation is the most frequently practiced method of determining blood loss during childbirth in the United States.\textsuperscript{22} In a review of 23 publications by Mavis Schorn to evaluate the accuracy of visual estimation of blood loss, some of the authors reported underestimation while others overestimation, and still others found inconsistency but without any particular pattern.\textsuperscript{22}
Other methods of measuring blood loss like the direct methods are probably the oldest reported methods of determining blood loss during child birth as it requires only containers for collection and a graduated container for measuring blood loss.\textsuperscript{22,30} It also requires some estimation of blood that maybe on gloves, gowns, linen, or other items. One limitation is that it is impossible to avoid all other types of fluids such as amniotic fluid or urine which if these fluids are inadvertently collected, the results may be inaccurate.\textsuperscript{22}

Ramadani in his study demonstrated that the amount of amniotic fluid absorbed in surgical swabs did not contribute to the difference found between intraoperative blood loss measured by more than one method.\textsuperscript{20} There may be failure to collect all the blood and to account for staining of various linen including those under the mother’s buttock or back. In addition, weighing blood by collecting all contaminated linen, towels, or swabs and the deduction of dry weight of these items will require a weight sensitive scale.\textsuperscript{22} Furthermore, it is important to ensure that only blood stained linen and not liquor soaked linen that are weighed to avoid spurious result and these blood stained materials should be weighed immediately to avoid error from evaporation.

Gravimetric evaluation of intraoperative blood loss was found to be an accurate method which can be recommended for use in clinical setting.\textsuperscript{3} However, several other studies revealed that this method can easily be taught but not really applicable in the operating room because the operating room setting requires a quick and accurate technique of assessing intraoperative blood loss that will enable immediate clinical intervention which gravimetry and visual estimation does not offer.\textsuperscript{15,16,22}
Duthie et al,\textsuperscript{31} in another study involving 62 patients (37 primiparas and 25 multiparas) showed that visually estimated blood loss was grossly inaccurate as the mean estimated blood loss was significantly lower than the mean measured blood loss with p-value of 0.00001 (p<0.05) in both groups. Within the 37 primiparas, the mean estimated blood loss was $260 \pm 12$ml and the mean measured blood loss was $401 \pm 29$ml while in the multiparas, mean estimated blood loss was $219 \pm 10$ml with mean measured blood loss of $318 \pm 41$ml. Their study revealed gross underestimation of blood loss and the significant difference between visual and laboratory estimated blood loss in their study was found to be dangerously high and unacceptable in clinical practice. This gross underestimation was largely due to failure to properly account for staining of various linen including those under the mother’s buttock and back during visual estimation and this is a major challenge when using this method.

In like manner, Prasertcharoensuk et al,\textsuperscript{32} in a study to determine the accuracy of blood loss estimation in the third stage of labour observed cases of underestimation when using visual estimates and the tendency to underestimate increased when blood loss was greater than 300ml. In contrast to reports of underestimation, Laarson et al,\textsuperscript{33} reported significant overestimations by birth attendants in caesarean births and visual estimates were over or underestimated in vaginal births without a consistent pattern.

Naveen et al,\textsuperscript{34} in another study involving 50 patients compared clinically estimated blood loss with blood loss calculated from laboratory haematocrit. They observed overestimation in 16 patients (32\%) and 34 cases of underestimation (68\%) and therefore concluded that in the perioperative period, clinical estimation of blood loss is inaccurate and should not be used alone to determine the need for red blood cell transfusion.
However, their study included general surgery, orthopaedic, urology, and plastic surgery patients, with general surgery patients constituting over 50% of their total sample size (26 out of 50 patients) and this might have constituted a bias in the representation of other specialties and may not be a true representation for all other surgeries. Also, during general surgery procedures, blood loss may be mixed with peritoneal and intestinal fluids in the suction bottle which can cause dilution and further encourage error in the interpretation of the results. In addition, this study did not involve patients undergoing caesarean section where blood loss might be mixed with amniotic fluid.

Furthermore, a similar study done by Abbasi et al,\textsuperscript{35} comparing visual estimation of blood loss with serial haemoglobin and haematocrit estimation in supratentorial craniotomy demonstrated wide variations between both methods. The researchers in their study involving fifty four (54) neurosurgical patients demonstrated a significant error of 76% of over or under estimation of blood loss with a poor correlation between estimated blood loss and calculated blood loss with a regression coefficient of 0.38.\textsuperscript{35} However, in their methodology, the estimated blood loss was carried out by four different anaesthetists involved in neurosurgery anaesthesia and therefore one cannot eliminate inter observer variability and bias. However, this result is in tandem with the previous studies mentioned above that showed poor correlation between the two methods.

Their findings appear to be in contrast to a study done by Ashraf and Hisham,\textsuperscript{23} for assessment of blood loss during caesarean section under general anaesthesia and epidural anaesthesia using different methods of estimating blood loss. The researchers compared visual estimates given by
obstetricians, anaesthetists and scrub nurses to blood loss derived from weighing of swabs and calculation using the formula by Bourke and Smith.\textsuperscript{36}

In their study, blood loss was significantly under-estimated when assessed visually by both obstetricians (528ml) and scrub nurses (493ml), whereas anesthetists (560ml) regardless of the expertise were able to give the closest figures to that of blood loss assessed by swab weighing method (578ml) while the calculated blood loss using Bourke and Smith formula was 627ml.\textsuperscript{23} In the above study, weighing of swabs was considered as the “gold standard” for comparing blood loss and the author opined that visually estimated blood loss by the anaesthetists appeared to have a high accuracy and without significant difference compared to estimates obtained from weighing of swabs.\textsuperscript{23} However, the effect of weighing swabs stained with a mixture of liquor and blood could adversely affect the result of the study. In addition, failure to immediately weigh the blood soaked materials could also lead to error in the result as evaporation could occur and would lead to reduction in the net weight of the materials.

Furthermore, an observational study done by Bose et al,\textsuperscript{37} to determine the discrepancy between actual blood loss and visually estimated blood loss, they compared estimates given by 24 obstetricians, 9 anaesthetists, 42 midwives, 11 gynaecological nurses, 12 theatre nurses and 5 health care assistants. The results showed that the anaesthetists overestimated by 4\% while the other professional groups underestimated by as much as 32\% and this substantiate the perception that, when compared to other professional groups the anaesthetists tend to overestimate blood loss. However, the anaesthetists were the most accurate estimators of blood loss, recording a median overestimate of just 4\% and the smallest interquartile range.
The anaesthetists’ tendency to ‘overestimate’ blood loss is almost certainly a compensatory response to surgical underestimation and his bid to be alert and preemptive in the diagnosis and management of intraoperative haemorrhage. Furthermore, daily exposure of the anaesthetist to bloody surgical fields for repeated number of times for different surgical procedures may contribute to their ‘estimating’ skill.

There is also evidence that midwives are relatively accurate in estimating blood loss. Kavle et al, reported nurse-midwives' ability to estimate blood loss during birth as accurate within 5ml of a laboratory determination; however, the higher the blood loss, the greater the imprecision of the estimate by under- or overestimating the loss. When a loss was > 200 ml, the mean difference from the laboratory finding was 62 ml either under- or overestimation. Glover also reported accuracy in midwife estimation of blood loss during a simulated birth; however, error increased when the blood loss was > 600 ml. Similarly, Budny et al, reported a strong positive association between calculated blood loss and blood loss estimates by junior and senior surgeons and senior anesthetists following burn surgery.

In contrast Kolb et al, showed the unreliability of visual estimation in a controlled study where a selected, known quantity of human blood was distributed on laparotomy pads. A variety of professionals who worked in the surgery area of a hospital were evaluated on their ability to estimate the quantity of blood. There were no differences among the groups of professionals or by amount of experience in their ability to accurately estimate blood loss.
Higgins conducted a similar study using a known amount of blood on sanitary pads to evaluate registered nurses' (from labour and delivery, emergency room, postpartum, and the operating room) ability to estimate blood loss and the results were similar with that done by Kolb et al with no difference between estimates from labour ward, delivery ward, emergency room and operating room nurses. Similarly, Buckland and Homer conducted simulated birth blood loss scenarios. Health care professionals were able to estimate small volumes of blood more accurately than large volumes and blood in containers more accurately than blood on sanitary pads or linens.

Tall et al, and Patton et al, conducted controlled simulation blood loss scenarios for emergency personnel. Estimations were so inaccurate that they suggested that emergency personnel should not waste time trying to visually estimate blood loss when that time could be used attending to the patient. Patton et al, suggested that field and hospital treatment should be provided based on vital signs, symptoms of shock, mechanism of injury, and comorbidities rather than visual estimates of blood loss.

Beer et al, conducted epistaxis simulations and found blood loss > 100 ml to be somewhat underestimated and > 500 ml to be grossly underestimated by medical and nonmedical personnel, with the nonmedical personnel being the most inaccurate. However, providing education through simulation exercises improves the ability of health care providers to estimate a predetermined quantity of blood volume on materials simulating clinical scenarios even though the estimates are still inaccurate, particularly with large volumes.
Other direct and objective methods of measuring blood loss like photometry and radioactive tagging of blood cells are expensive, time consuming and impractical in the operating room.\textsuperscript{50-51} Photometry involves collection of all blood stained materials such as abdominal swabs, pads and gauze and placing them into an automatic extractor such as Stomacher Lab-Blender, this machine will provide a quick extraction of the blood with the aid of 5\% sodium hydroxide solution added to the machine. The blended material will be centrifuged and filtered and the optical density of the solution will be read to determine the haemoglobin concentration using a spectrophotometer.\textsuperscript{22}

Whereas, the radioactive tagging of red blood cells to determine blood loss involves the use of radioactive $^{51}$Cr (Chromium-51). $^{51}$Cr-tagged red cells are use to determine the patients’ blood volume before and after the operation using the principle of Fick’s dilution technique. The differences between the preoperative and postoperative red cell masses are calculated as absolute values and this represents the blood loss\textsuperscript{22}. Although both methods provides a reliable and accurate means of measuring blood loss, they are expensive and impractical in the operating room.\textsuperscript{22}

Visual estimation remains the commonest method of assessing intraoperative blood loss in most institutions in sub Saharan Africa even though it has been reported as inaccurate in some studies.\textsuperscript{22,41} In spite of this, visual estimation of blood loss is still routinely used by the anaesthetists, obstetricians, urologists, orthopaedic surgeons and nurses.\textsuperscript{52,53} Intraoperative estimation of blood loss for caesarean section is both poorly reproducible and typically an underestimate.\textsuperscript{54}
Anaesthetists need tools to monitor haemoglobin quickly and accurately to avoid delayed intervention, which can result in patient’s morbidity. The need for a better assessment of blood loss to prevent over transfusion or under transfusion led to the formulation of guidelines for transfusion of red cells by the Association of Anaesthetists of Great Britain and Ireland (AAGBI) in 2008 stating that haemoglobin concentration or haematocrit should be monitored perioperatively and should guide red cell transfusion.

This may be achieved by formal laboratory investigation if time allows or by the use of point-of-care monitoring devices that can provide guidance e.g. blood gas analyzers or HemoCue device. Haemoglobin determination using a HemoCue can offer a direct measurement of blood loss and thereby allow for immediate intervention by the attending physician within the operating room. Electronic and portable haemoglobinometer such as HemoCue provide fast haemoglobin result with accuracy and can be operated using battery or mains electricity. It also has a high accuracy with correlation of 0.99 when compared with the reference method (automated hematology analyzers).

Spielmann et al, in a study to determine the accuracy and reproducibility of the HemoCue (BHaemoglobin Model) for Hb determination, compared the results from HemoCue with that obtained from a Sysmex XE 2100 automated analyzer in children undergoing major surgery. A total of 256 arterial blood samples were collected at several intraoperative time and HemoCue exhibited good reproducibility and negligible bias when compared with the XE 2100. Potential clinically significant differences were observed beyond a range of 20g/L in only two cases (i.e., 0.8%). It was concluded that the HemoCue showed reliable test results in the intraoperative setting.
Furthermore, Richards et al.\textsuperscript{60} compared Hb values measured in venous and capillary samples (toe and thumb) in patients undergoing caesarean section under neuraxial anesthesia using the HemoCue (model not reported) and laboratory instrumentation (again, the analyzer model was not reported). In the study, the mean bias versus results obtained in venous blood samples tested in the laboratory was $-2 \pm 16 \text{ g/L}$ (HemoCue, capillary blood from toe), $-1 \pm 18 \text{ g/L}$ (HemoCue, capillary blood from thumb), and $-2 \pm 16 \text{ g/L}$ (HemoCue, venous blood).

No significant difference was observed in the measured values and the author opined that HemoCue remains useful as a clinical guide in the acute setting, though it should not replace formal laboratory venous sampling, which remains the gold standard. The result also showed that either the thumb or toe is suitable as sites for capillary sampling but gave preference to the use of the foot since it was numb from anaesthesia.\textsuperscript{60}

In Contrast, Frasca et al.\textsuperscript{61} conducted a prospective observational study to determine the reliability of HemoCue in critically ill patients, they compared the HemoCue estimated haemoglobin result from capillary sample with values from laboratory haemoglobin analyzer and came to the conclusion that capillary HemoCue is not accurate enough to base therapeutic decisions such as blood transfusion and that the performance of the method is improved with the use of arterial blood. Their finding was largely as a result of subcutaneous oedema interfering with the sampling as critically ill patients often retain fluid within the subcutaneous tissue.\textsuperscript{61}

However, Giroud et al.\textsuperscript{62} in a more recent and similar study comparing haemoglobin measurement methods in the operating theatre observed that bedside haemoglobin measuring methods differ in their agreement to a laboratory hematology analyzer but the difference was not significant enough to warrant unnecessary transfusion. In addition, the use of the Hemocue
device as a point-of-care monitor is stated as a specific recommendation in the latest report of the Confidential Enquiries into Maternal and Child Health.\textsuperscript{15}

The HemoCue is known to be convenient and accurate when used in line with the recommended sampling technique.\textsuperscript{13} The HemoCue is widely used in maternity units in the United Kingdom both intra-operatively and in the diagnosis and management of ante- and postpartum haemorrhage.\textsuperscript{60,63}

Johanna et al.\textsuperscript{64} in a study involving 730 trauma patients, showed that haematocrit and haemoglobin behaved as identical parameters in trauma patients and both correlate in all ranges demonstrating that the idea that haematocrit is different from haemoglobin in acute blood loss is a misconception and thus recommends that physicians should use either haematocrit or haemoglobin according to personal or hospital practice.

Haemodilution is frequently induced by volume loading with a crystalloid solution before lumbar extradural anaesthesia or spinal anaesthesia is established and the aim is to increase arterial blood pressure by increasing blood volume and has been frequently cited as a limitation in estimating blood loss during caesarean section using spinal anaesthesia.\textsuperscript{65} It is generally stated that intravenous infusion of isotonic crystalloid solution can increase blood volume by 20-25\% of the administered volume with the potential to cause a decrease in packed cell volume.\textsuperscript{66-68}

Previous studies done to describe the time course of increased haemodilution in hypotension induced by extradural anaesthesia observed that arterial hypotension (\textgreater{}25\% drop in baseline value) was followed by increased haemodilution after a delay of as much as 15 minutes.\textsuperscript{65,69}
Furthermore, marked haemodilution has also been described in parturients who developed hypotension during onset of regional anaesthesia before Caesarean Section.\textsuperscript{65}

However, contrary to these statements, Hahn and Svensen,\textsuperscript{67} in a different study involving 14 healthy males (aged 25-36 years), and 6 healthy females (aged 23-46 years) revealed only a 10\% increase in blood volume following a continuous rapid infusion of large volume (>50 ml/min) of crystalloid solution (Ringer’s lactate) in adult male subjects and even at this high rate the infusion has to continue for 40 minutes (and requires 2000 ml) to yield this dilution. In their study, they noticed difficulty in achieving pronounced haemodilution and reduced packed cell volume which was explained to be due to rapid elimination of the fluid. The associated changes in blood volume and packed cell volume are very transient and insignificant when volumes of 10-20 ml/kg are administered as a single loading dose as seen during caesarean section.\textsuperscript{67,70}

Similarly, Horowitz et al,\textsuperscript{71} in their study mentioned that although 2-3 litres of isotonic solution were given during caesarean section, no effect of haemodilution appeared on the haematocrit levels which were consistently stable. Accurate assessment of blood loss is a prerequisite in maintaining a good transfusion practice as inadequate assessment may lead to over or under transfusion.\textsuperscript{3} Over transfusion is associated with the risk of immunological reaction, transmission of infections e.g. HIV, Hepatitis B and C and prion transmission.\textsuperscript{72}

Furthermore, blood and blood products are scarce commodities in sub Saharan Africa where the practice and culture of blood donation is not routine.\textsuperscript{2} It is therefore important that anaesthetists be equipped with accurate methods of assessing blood loss to prevent inappropriate use of this commodity.
Chusa SC et al,\textsuperscript{73} in a retrospective study done in a tertiary hospital in Australia to determine the incidence of blood transfusion in caesarean section revealed a transfusion rate of 0.63\% (14 out of 2,202 patients) and the risk of blood transfusion for elective and emergency caesarean section was 3.9 per 1000 and 9.8 per 1000 respectively.

In contrast, several studies on the incidence of red blood cell transfusion during caesarean section in sub Saharan Africa where anaesthetists often depend on visual estimates and physiological variables alone as trigger for transfusion showed high transfusion rate due to inaccuracy of the methods employed.\textsuperscript{4-6} In addition, Ozumba et al,\textsuperscript{6} in their study in Enugu revealed a transfusion rate as high as 25.2\% during caesarean section. While Faponle AF et al,\textsuperscript{4} and Anorlu RI et al,\textsuperscript{5} in separate studies reported a transfusion rate of 8.9\% and 12.1\% respectively.\textsuperscript{4,5}

Desalu et al,\textsuperscript{2} in a study done at the Lagos University Teaching Hospital (LUTH), Nigeria reported that anaesthetists using physiological changes and visual estimates were able to achieve 62\% appropriate blood transfusion. It therefore implies that 38\% of patients were at risk of inaccurate blood loss estimation and this significant population will therefore benefit from an improved or augmented technique of assessing intraoperative blood loss.

Therefore, the need to compare the accuracy of visual estimation with a point-of-care haemoglobin estimation (using HemoCue) during caesarean section becomes imperative in order to assess how accurate the method has been and the need for any improvement.
CHAPTER THREE
PATIENTS AND METHODS

STUDY LOCATION:

The study was carried out on pregnant women at term undergoing elective caesarean section at the University of Nigeria Teaching Hospital Enugu. It is a 700-bedded tertiary hospital located in South East Nigeria.

ETHICAL APPROVAL:

Ethical clearance for the study was obtained from the Hospital Research and Ethics Committee (HREC) and informed written consent was also obtained from each patient recruited for the study.

SAMPLE SIZE ESTIMATION:

Sample size calculation was based on a previous study by Ashraf et al.\textsuperscript{23} where visual estimated blood loss was compared to haematocrit calculated blood loss during caesarean section.

In their study, visually estimated blood loss and haematocrit calculated blood loss were 528±143.2ml and 627±180.6ml respectively.

The sample size was calculated with a significance level of 5% and power of study of 80%.

The following formula was used.

$$N = \frac{(A+B)^2 \times 2 \times SD^2}{(DIFF)^2}$$
Where N= sample size (double for total sample)

SD= standard deviation of primary outcome variable (estimated blood loss for caesarean section from previous study) in this case 143.2ml.\textsuperscript{23}

DIFF= difference from previous study between both methods (99ml).\textsuperscript{23}

A 10% increase in the difference from the previous study above=108.9ml

A= based on significance level of 5% = 1.96

B= based on power of study of 80% = 0.84

\[ N = \frac{(1.96 + 0.84)^2 \times 2 \times (143.2)^2}{(108.9)^2} = 27 \]

\[ 27 \times 2 = 54 \]

Using 10% attrition of 5.4, sample size = 54+5.4= 59.4 ~ 60

Calculated sample size was approximately 60, and a total of 60 patients were recruited for this study.

**PATIENTS’ SELECTION**

After obtaining approval from the Hospital Research and Ethics Committee, and informed written consent from the patients, a total of 60 patients of American Society of Anesthesiologists (ASA) physical status I or II were enrolled into this double blind, prospective, non randomized, controlled comparative study in which each patient acted as her own control.
**INCLUSION CRITERIA**

- Pregnant women at term presenting for elective caesarean section.
- ASA I or ASA II patients undergoing elective caesarean section
- Patients for caesarean section under subarachnoid block.

**EXCLUSION CRITERIA**

- Patient with pre-operative anaemia with haemoglobin ≤8gm/L
- Dehydrated patients
- Patient at risk of massive intraoperative haemorrhage e.g. major placenta praevia
- Patients with severe co-morbidities e.g. severe cardio-respiratory disease, recent myocardial infarction and stroke

**BLINDING**

The researcher and the patients were not aware of the calculated blood loss using the HemoCue prior to the time of making visual estimate of intraoperative blood loss. However, the researcher had the responsibility to alert the attending physician whenever haemoglobin level falls ≤7gm/L using the HemoCue.
**PROCEDURE**

All patients were seen and reviewed the evening before surgery. The patient’s age, weight, indication for caesarean section, parity, and gestational age were taken and recorded. History was taken, general and systemic examination done and the patients were classified using the ASA physical health status. Routine investigations (haemoglobin concentration and urinalysis) were done and two units of blood were grouped and cross-matched for each patient. A written informed consent was obtained and patients were fasted for at least 6 hours for solids and at least 2 hours for clear fluids before the operation. Each patient received ranitidine 150mg orally and metoclopramide 10mg orally, the night before and on the morning of the surgery.

On the morning of surgery, the availability and functionality of the anaesthetic machine, endotracheal tubes, laryngoscopes, stilletes and suction machines were ascertained. Laryngeal mask airway, gum elastic bougie, face mask, and resuscitation drugs such as ephedrine, atropine and adrenaline were all made available in the theatre.

In the theatre, monitoring was done using a multi-parameter monitor (DASH 4000 Monitor; GE Medical systems, USA) having electrocardiogram, pulse oximetry, Non invasive blood pressure, and temperature monitors. The patient’s baseline vital signs were taken and documented.

Intravenous access was secured using 16-guage cannula and patients were preloaded with warm normal saline (10ml/kg) using a volumetric infusion pump (IVAC 560, San Diego, CA, USA). The patients’ preoperative laboratory haemoglobin was documented and the preoperative haemoglobin ($h_i$) obtained prior to preloading and after preloading ($h_p$) using the HemoCue was also documented.
After preloading with normal saline (10ml/kg), the patients were placed in the sitting position, while the anaesthetist scrubbed and put on sterile gown and gloves. The lumbar region was then cleaned and draped and L3-L4 interspace identified using the iliac spines as landmarks. The skin, subcutaneous tissue and interspinous ligament were infiltrated with 2ml of 2% lignocaine. Using a 25G pencil point (Whitacre) spinal needle passed through a 21G hypodermic needle as an introducer, the subarachnoid space was located and with drainage of clear cerebrospinal fluid 2.5ml of 0.5% hyperbaric bupivacaine was administered into the subarachnoid space.

After injecting the hyperbaric bupivacaine into the subarachnoid space the punctured site was covered with sterile dressing and the patients were slowly returned back to the supine position with head and shoulders supported on a pillow and with a 15 degree left lateral tilt using a wedge. The vital signs were measured and recorded immediately after the spinal technique. The level of the sensory block was assessed using cotton wool soaked in alcohol until a block height of T4-T6 was achieved, after which surgery was allowed to proceed.

Maternal vital signs and oxygen saturation were monitored at 5 minute intervals. Intravenous fluids for these patients was restricted to the initial preload (10ml/kg) and the maintenance fluid administered to the patients using 10ml/kg in the first one hour and 5ml/kg in the subsequent hour and this was delivered with the aid of the infusion pump.

The blood pressure was maintained within 25% of baseline with 3mg boluses of ephedrine when indicated. Urine output was monitored via urethral catheterization to assess fluid maintenance and adequate tissue perfusion. Total urine output was recorded for all the patients.
After skin closure the researcher visually estimated the blood loss and documented it as \(v_f\) and this was followed by haemoglobin estimation by the researcher using HemoCue which was also documented as \(h_f\). The Researcher estimated the blood loss by counting the blood soaked abdominal mops and gauze pieces and multiplying them by the estimated volume of blood each would hold; fixed size mops and gauze were used. A fully soaked and dripping abdominal swab (10×10 inches) was taken as containing 100ml of blood while a piece of gauze (4×4 inches) was assumed to contain 10ml of blood, while blood lost to suction bottles and that lost in and around the operating field mixed with liquor were estimated before and after suctioning of the liquor.

At the delivery of the foetus, intravenous oxytocin 5 IU bolus was given and an infusion of 30 IU of oxytocin in 500ml of normal saline was administered to help maintain uterine contraction. Neonatal outcome was documented after assessment was done using Apgar score at 1 and 5 minute intervals.

The total blood loss and the duration of surgery were documented in the data collection form. At the end of the surgery, patients were taken to the recovery room and post operative vital signs, fluid input and output were monitored and documented. In the recovery room, post operative pain was managed using intravenous tramadol 1mg/kg stat and intravenous ketorolac 0.5mg/kg stat. Thereafter, pain relief was maintained according to the departmental protocol.

The blood samples for HemoCue estimation were taken from a skin prick on the thumb of the non-cannulated arm. All capillary samples were taken by the researcher. The capillary samples were taken strictly according to the manufacturer’s recommendation, which includes choosing a suitable digit for sampling, making a skin puncture that will allow a ladybird size drop of blood to be expelled, drawing up the blood sample with the cuvette ensuring that the entire chamber is
filled (not only the circular section) and wiping off the excess on absorbent material taking care not to siphon out the content. This sample was then placed into the HemoCue® 201+ (AB Medical Inc, Angelholm. Sweden) device and the results were displayed on the screen in less than a minute. The visually estimated blood loss and time were noted.

Other information on the perioperative events including the visually estimated and HemoCue estimated blood loss was documented on a data collection form. (See Appendix I). The actual blood loss was calculated from a modification of the Gross formula given below.74

Haematocrit (Hct) derived from HemoCue = 2.953 × Hb g/dl.64,75

\[
\text{ABL} = \frac{\text{BV} \times (\text{Hct}_i - \text{Hct}_f)}{\text{Hct}_m}
\]

Where ABL = Actual blood loss

BV = is the blood volume calculated from the patient weight in Kg (65ml/Kg).72

Hct\(_i\) = haematocrit initial

Hct\(_f\) = haematocrit final

Hct\(_m\) = the mean of the initial and final haematocrits

Calculated blood loss using HemoCue = \[
\frac{\text{BV} \times (2.953 \times h_i - 2.953 \times h_f)}{2.953 \times h_m}
\]

The visually estimated blood loss was designated as estimated blood loss (EBL) while the blood loss calculated from the HemoCue haemoglobin was designated as actual blood loss (ABL). The
average blood loss (AVG-BL) was derived from each patient which was the mean of the actual and estimated blood loss.
STATISTICAL ANALYSIS

Statistical Package for Social Sciences version 17.0 was used for data entry and statistical analysis. The mean, standard deviation and range were used to analyze basic demographics.

To compare blood loss assessment using visual estimation and the HemoCue test, paired t-test, Pearson’s correlation and the Bland and Altman’s method of assessing agreement between two methods of clinical measurement were used. The Bland and Altman statistical test compares two methods of clinical measurement by plotting the difference between the two values obtained by each method against the “actual” value estimated by calculating the mean of the two values. A large difference between the two methods (mean difference) represents “bias” of one method over the other.
CHAPTER FOUR

RESULTS

A total of 60 parturients for elective caesarean section were recruited for this study. The ages of the parturients were between 21-37 years with a mean of 27.66 ± 3.13 years, their mean body weights ranged from 62-95kg with a mean of 80.22 ± 5.77kg (Table 1). The indications for caesarean section as seen in Figure 1 included; cephalo-pelvic disproportion (33.33%), post datism (25%), breech presentation (8.33%), maternal request (8.33%), mal-position/mal-presentation (16.67%), oligohydramnios (8.33%). A total of 50 patients were ASA class I while the remaining 10 patients were ASA class II (Figure 2).

The duration of surgery varied between 60-90 minutes with a mean of 75.22 ± 7.22 minutes. The total volume of fluid given to the patients ranged from 1200-1850ml with a mean of 1555.44 ± 113.13ml (Table 2). The relationship between laboratory haemoglobin concentration of the patients’ using an auto-analyzer (GEM premier 3000) and that of Hemocue haemoglobin concentration was determined using Pearson’s correlation (p=.0001, n=60, r=0.89) Figure 3. This result suggests that Hemocue has a high accuracy with correlation of 0.89 when compared with a reference method (automated hematology analyzer) Figure 3. Further comparison of the values obtained from the two methods of haemoglobin estimation was done using a paired t-test and no significant difference was observed (p value = 0.07) as seen in Table 3.

The patients’ mean haemoglobin using Hemocue before preloading with 10ml/kg of normal saline over 10-20 minutes was 11.36 ± 0.77g/dl, and after preloading was 11.23 ± 1.15g/dl.
There was a slight drop in the mean haemoglobin level but the drop was not significant (p value = 0.14, paired t-test) as seen in Table 4.

The mean visual estimated blood loss for caesarean section was 470.32 ± 221.66ml with a range of 200-1100ml while the mean calculated blood loss (CBL) using HemoCue was 563.47 ± 203.53ml with a range of 180.7-1074.5ml. Visual estimation was less than Hemocue calculated blood loss (underestimation). The difference between visually estimated blood loss and calculated blood loss was not significant with a p value of 0.125 (paired t-test) Table 5.

A Pearson product-moment correlation coefficient was computed to assess the relationship between estimated blood loss and calculated blood loss using Hemocue. There was a positive correlation between both methods (r = 0.66, n = 60, p = 0.002). A scatter plot summarizes the results (Figure 4). Overall, there was a reasonable, positive correlation between visually estimated blood loss and Hemocue calculated blood loss.

Further analysis was done using Bland and Altman statistical test. Estimated blood loss and calculated blood loss were used to determine the difference in blood loss (DIFF-BL). The average blood loss (derived from the mean of both methods of estimation) was 456.22 ± 177.46ml (Table 6). The bias (mean difference between both methods) was negligible (+45.25ml) and the limit of agreement (mean difference ± 2SD) between both methods was -222.20 – 275.43ml (Table 6). The bias and limit of agreement between both methods of assessing blood loss was small and not significant enough to cause error in clinical judgment in this group of patients.
To obtain the Bland-Altman plot, the difference in blood loss was plotted on the Y-axis with the average blood loss on the X-axis (Figure 5). From the plot it was observed that at average blood loss between 200-500ml, the values were around the “0” point on the Y-axis which connotes good level of agreement between both methods of determining intraoperative blood loss but this scatters further away around the “0” point at average blood loss of > 500ml which implies that as blood loss increases above 500ml the error margin between visually estimated blood loss and Hemocue calculated blood loss widens.

The patients’ vital signs trends during the surgery are reflected in Figures 6-8. Systolic blood pressure decreased significantly by 16mmHg (p = 0.001, paired t-test) while diastolic pressure decreased by 10mmHg (p= 0.015, paired t-test) in the first 10min of spinal anaesthesia, subsequently, there was a gradual rise in the systolic and diastolic pressure. In 33% (20) of the paturients, hypotension was managed with 3mg aliquots of ephedrine. No significant change in the pulse rate (p =0.086, paired t-test) and the respiratory rate (p = 0.776, paired t-test) were observed.

Neonatal outcome was good with Apgar score in the range of 7-9 in 1 and 5 minute interval (Table 7).
TABLES

TABLE 1: Demographic characteristics.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>27.66 ± 3.13</td>
<td>21-37</td>
</tr>
<tr>
<td>Weight(Kg)</td>
<td>80.22 ± 5.77</td>
<td>62-95</td>
</tr>
<tr>
<td>Gestational age (weeks)</td>
<td>38.43 ± 1.44</td>
<td>37-41</td>
</tr>
<tr>
<td>Parity</td>
<td></td>
<td>1-4</td>
</tr>
<tr>
<td>Nulliparous</td>
<td>45 (75%)</td>
<td></td>
</tr>
<tr>
<td>Multiparous</td>
<td>15 (25%)</td>
<td></td>
</tr>
<tr>
<td>Grand multiparous</td>
<td>0 (0%)</td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Time, duration and volume of fluid given.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Range</th>
<th>Mean</th>
<th>±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of preload (ml)</td>
<td>620-950</td>
<td>850.67</td>
<td>±110.21</td>
</tr>
<tr>
<td>Duration of preload (minutes)</td>
<td>10-20</td>
<td>14.25</td>
<td>±2.08</td>
</tr>
<tr>
<td>Total volume of fluid given(ml)</td>
<td>1200-1850</td>
<td>1555.44</td>
<td>±113.13</td>
</tr>
<tr>
<td>Duration of surgery (minutes)</td>
<td>60-90</td>
<td>75.22</td>
<td>±7.22</td>
</tr>
<tr>
<td>Urine Output (ml)</td>
<td>150-350</td>
<td>170.45</td>
<td>±30.45</td>
</tr>
</tbody>
</table>
Table 3: Comparison of laboratory Haemoglobin versus Hemocue haemoglobin.

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>Mean ±SD</th>
<th>P-value</th>
<th>95% CI of the difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory Haemoglobin (g/dl)</td>
<td>9.5-14.1</td>
<td>11.47 ±1.14</td>
<td>0.0021</td>
<td>Lower: 0.1424 Upper: 0.1424</td>
</tr>
<tr>
<td>Hemocue Haemoglobin (g/dl)</td>
<td>9.6-14.0</td>
<td>11.40 ± 1.01</td>
<td>0.07</td>
<td></td>
</tr>
</tbody>
</table>

Level of significance ≤0.05
Table 4: Effect of preload on the mean Haemoglobin using Hemocue.

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>Mean ±SD</th>
<th>P-value</th>
<th>95% CI of the difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemoglobin before preload (g/dl)</td>
<td>10.0-12.7</td>
<td>11.36 ±0.77</td>
<td></td>
<td>Lower 0.9060 Upper 1.1514</td>
</tr>
<tr>
<td>Haemoglobin after preload (g/dl)</td>
<td>9.8-12.3</td>
<td>11.23 ±1.15</td>
<td>0.14</td>
<td></td>
</tr>
</tbody>
</table>

Level of significance ≤0.05
Table 5: Visual estimated blood loss and HemoCue calculated blood loss for Caesarean Section.

<table>
<thead>
<tr>
<th>Blood loss during caesarean section</th>
<th>Range</th>
<th>Mean ± SD</th>
<th>p-value</th>
<th>95% CI of the difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visually estimated blood loss at skin closure (ml)</td>
<td>200-1100</td>
<td>470.32 ± 221.66</td>
<td>-13.65 - 102.34</td>
<td></td>
</tr>
<tr>
<td>HemoCue calculated blood loss at skin closure (ml)</td>
<td>180.7-1074.5</td>
<td>563.47 ± 203.53</td>
<td>0.125</td>
<td></td>
</tr>
</tbody>
</table>
Table 6: Measurement of agreement between both methods.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Mean ± SD</th>
<th>Standard error of mean</th>
<th>Limit of agreement (mean±2SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIFF-BL (ml)</td>
<td>-624.5 - +781.6</td>
<td>+45.25 ± 116.16</td>
<td>27.55</td>
<td>-222.20-275.43</td>
</tr>
<tr>
<td>Average blood loss (ml)</td>
<td>202.06 – 911.58</td>
<td>456.22 177.46</td>
<td>20.44</td>
<td></td>
</tr>
</tbody>
</table>
Table 7: Neonatal outcome

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonatal weight (kg)</td>
<td>2.5-5.5</td>
<td>3.08 ± 0.568</td>
</tr>
</tbody>
</table>

Apgar score

<table>
<thead>
<tr>
<th>Time</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 minute</td>
<td>7-9</td>
</tr>
<tr>
<td>5 minutes</td>
<td>7-9</td>
</tr>
</tbody>
</table>
FIGURES

Figure 1: Indications for Caesarean Section.
Figure 2: Distribution of patients by ASA classification.
Figure 3: A simple scatter plot of Laboratory (lab) Hb and Hemocue (HM) Hb.
Figure 4: A simple scatter plot of EBL and CBL.
Figure 5: Bland and Altman plot.
Figure 6: Trends of haemodynamic parameters.
Figure 7: Trend of Respiratory rate.
Figure 8; Trend of SpO₂.
CHAPTER FIVE

DISCUSSION

The study revealed that visual estimation was found to be less than Hemocue calculated blood loss. However, visual estimation of intraoperative blood loss by the anaesthetist did not significantly differ from Hemocue calculated blood loss. The average blood loss using visual estimation in this study was $470 \pm 221\text{ml}$ with a range of 200-1100ml. This finding agrees with the results of previous studies done by Duthie et al\textsuperscript{26} and Fauzia et al.\textsuperscript{27} Duthie et al,\textsuperscript{26} in their study, observed a mean estimated blood loss of 425ml with a range of 100-1300ml during caesarean section.

In the same way, Fauzia et al,\textsuperscript{27} in their work observed that the average blood loss estimated by anaesthetist was $498 \pm 176\text{ml}$ while visually estimated blood loss by obstetrician was $592 \pm 222\text{ml}$. In their study, the estimated blood loss by the anaesthetists were surprisingly lower than those of the obstetricians in contrast to the general belief that anaesthetists often tend to ‘overestimate’ blood loss.\textsuperscript{37} Their study included both elective and emergency caesarean sections, however, the estimated blood loss by the anaesthetists corroborated with the index study which implies that there is no significant difference in blood loss during elective or emergency caesarean section.\textsuperscript{23-25}

Furthermore, Ashraf et al,\textsuperscript{23} in a study to assess blood loss during caesarean section observed that visually estimated blood loss by nurses, obstetricians and anaesthetists was within the range of 350-1000ml. In their study, the anaesthetists gave the closest estimation of blood loss (mean EBL = 560ml) when it was compared with the results obtained by weighing of swabs.
In contrast, Imarengaiye et al and Oluwarotimi et al, in separate studies observed the mean estimated blood loss during caesarean section to be as high as 1310.8 ±991.8 ml and 848.3 ± 736.2 ml respectively. Interestingly, both studies were retrospective in nature and were focused on evaluating blood reservation and utilization policy during caesarean section and also included patients who received intraoperative blood transfusion. This was in contrast with the index study which was a prospective study, where patients who received intraoperative blood transfusion or whose haemoglobin level dropped to ≤7g/dl were excluded.

Furthermore, several anaesthetists were involved in estimating blood loss in the above studies compared to a single anaesthetist in this index study and this could have led to inter-observer bias. The researcher (anaesthetist) in the index study was solely responsible for visual estimation of blood loss so as to eliminate inter-observer variability.

There is paucity of report on the use of Hemocue in determining intraoperative blood loss during caesarean section globally. In this study, the HemoCue calculated blood loss was 563 ± 207ml with a wide range of 181-1075ml. The result is in tandem with previous work done using laboratory haematocrit values (model not reported), where the measured blood loss was within the range of 66-1290ml during caesarean section with a mean of 627ml.23

Duthie et al, in a different study carried out to measure blood loss during caesarean section, reported a mean blood loss of 487ml with a range of 164-1438ml. However, the measured blood loss was done using alkaline hematin method which is different from the technique adopted in the current study. A review of articles on various methods of measuring blood loss revealed that only few published studies have quantified blood loss with acid or alkaline hematin, and there are none in developing countries.22
In another study done to measure blood loss during caesarean section using patients’ laboratory haemoglobin (model not reported), an average blood loss of 787±519ml was observed.\textsuperscript{27} The methodology in the above study differed significantly from the index study as the final Hb check was done 48 hours after surgery and some of the patients who had received blood transfusion in the immediate post operative period were included in the study and these could account for the discrepancy in their outcome compared to the index study.

In addition, two previous studies done by Ramadani et al\textsuperscript{20} and Gol et al\textsuperscript{25} using gravimetric method to measure blood loss during caesarean section revealed a mean blood loss of 669ml and 626ml respectively. The slight increase in their values compared to the index study could be attributed to the different methods of assessment employed by the investigators and the inclusion of patients undergoing general anaesthesia. It is well documented that measured blood loss varies with the method of assessing blood loss and there are publications that have reported greater blood loss with general anaesthesia compared to spinal anaesthesia.\textsuperscript{20,26}

There was no significant difference between the mean visual estimated blood loss and the mean HemoCue calculated blood loss (p=0.125, paired t-test). The relationship between both methods of estimating blood loss was assessed using Pearson’s correlation and the result showed a high correlation between both methods (r=0.66). This finding agrees with the study done by Laarson et al,\textsuperscript{33} where he observed moderate correlation (r=0.55) between estimated and measured blood loss in caesarean section. Similarly, Budny et al,\textsuperscript{40} in their work, established a strong positive association between calculated blood loss and visually EBL.

In contrast, Naveen et al,\textsuperscript{34} compared visually EBL with laboratory calculated blood loss and found poor correlation between both methods with interclass correlation coefficient of 0.34.
Their study was done on general surgery patients, neurosurgical and orthopaedic patients. In addition, more than one anaesthetist was responsible for estimation of blood loss and this could account for the disparity in their result compared to the index study.

Similarly, Abbasi et al.\textsuperscript{35} in their work reported poor correlation between visual EBL and haematocrit CBL in supratentorial craniotomy with a regression coefficient of 0.38. Their study was conducted on neurosurgery patients whose procedure lasted between 2-6 hours, with an average blood loss of 945ml. The large blood loss associated with supratentorial craniotomy could account for the poor correlation between both methods as visually estimated blood loss becomes more inaccurate as blood loss increases. In addition, the use of irrigation fluid during craniotomy could also contribute to error in their estimation of blood loss.

However, the interpretation of test of significance and correlation coefficient when comparing two methods could be misleading as data which seem to be poor in agreement can produce quite high correlations.\textsuperscript{76} Therefore, further analysis to measure the degree of agreement between both methods of clinical measurement recommended by Bland and Altman was also employed. The result showed good agreement between the two methods of assessing blood loss with a bias of +45.25ml. The level of agreement was better at blood loss of between 200-500ml. At blood loss >500ml the difference between both method was between 500-750ml which was too wide and represent an unacceptable margin if it should be solely relied upon for clinical judgment.

These findings corroborates with previous studies where blood loss was visually estimated with reasonable accuracy among anaesthetists and the error in clinically estimated blood loss was typically higher if the measured blood loss was more than 600ml.\textsuperscript{31,38} Similarly, Kavle et al\textsuperscript{38} in
their study found visual estimation of blood loss by Zanzibari nurse-midwives to be accurate when compared to laboratory CBL with a mean difference of 5ml. In the above study, the mean difference increased to 62ml when blood loss > 200ml, a pattern that was in keeping with the finding in this index study. Furthermore, Glover, in his study had reported greater error in the estimation of larger blood losses by health professionals which was also in keeping with this study.39

In this research, the patients’ laboratory haemoglobin and Hemocue haemoglobin were compared and a very high correlation was observed (r=0.89). The observation was in keeping with several other studies which suggested that Hemocue is an accurate device in assessment of haemoglobin in obstetric patients. Fabian Sanchis-Gomer et al, in their study compared HemoCue Hb 201 system with the reference method according to International Council For Standardization In Haematology (ICSH) and found a correlation of 0.99. This result reflects a near perfect relationship between both methods and further validates the accuracy of Hemocue in assessing haemoglobin level in obstetric patients.

In addition, no significant change in patients’ haemoglobin level before and after preloading with normal saline was noted (p=0.14). The result aligns with the study done by Swensen and Hahn where they observed that the associated changes in blood volume and packed cell volume are very transient and insignificant when volumes of 10-20ml/kg are administered as a single loading dose as seen during caesarean section. In another study corroborating the above finding, 2-3litres of isotonic solution were given during caesarean section and no effect of haemodilution appeared on haematocrit levels.71
In contrast, in another study, it was observed that hypotension was followed by increased haemodilution after a delay of as much as 15 minutes.\textsuperscript{69} However, the study was conducted on male patients undergoing short urological procedures under epidural anaesthesia, and the difference in their patient selection and the use of extradural anaesthesia may account for the disparity in their findings.

In the index study, the total volume of fluid given to the patients was between 1200-1850ml, as fluid administration was restricted to preload and fluid maintenance and intraoperative hypotension was managed with 3mg boluses of ephedrine to minimize haemodilution from excessive fluid administration. Most of the episodes of hypotension occurred in the initial 10 minutes after subarachnoid block. 20 patients received vasopressor (ephedrine) for management of hypotension.

Caesarean section is known to be associated with varying degrees of blood loss assessed by diverse methods such as gravimetry, colorimetry, radioisotope tagging of red cells, and photometry.\textsuperscript{80} However, visual estimation in this study was found to be reasonably accurate with marginal error, and a greater imprecision was found with higher losses of greater than 500ml.
CONCLUSION

In conclusion, visually estimated blood loss was closely related to HemoCue calculated blood loss, and even though visually estimated blood loss was less than Hemocue calculated blood loss the margin was not significant and couldn’t have led to error in clinical judgment such as over transfusion or unrecognized massive maternal haemorrhage.
RECOMMENDATIONS

- Visual estimation of blood loss during caesarean section should not be discouraged as it is cost free and can be rapidly done with reasonable level of accuracy in experienced hands.

- Clinicians should be trained and educated on this skill by creating mock clinical scenario mimicking real blood loss in order to improve their accuracy of estimation.

- HemoCue should be used routinely during caesarean section to complement clinical estimation of intraoperative blood loss especially in obstetric cases where large blood loss is anticipated for example in major placenta praevia, abruption placenta, uterine rupture, and uterine tear and also for use by trainees or junior Anaesthetists.

- The users of the device should be adequately trained as with any medical device about test requirements, performance, limitations and potential interferences.
LIMITATIONS

In this study, mathematical calculation using modified Gross formula was adopted to determine measured blood loss with Hemocue. And there are reports suggesting that all theoretical relationship between blood loss and changes in haematocrit often leads to ‘overestimation’ of blood loss.\textsuperscript{81}

Currently, there is paucity of reports on the use of Hemocue to determine intraoperative blood loss.
REFERENCES


18. Prual A, Bouvier-Colle M-H, Bernes Lide, Breast G. Severe maternal mortality from
direct obstetric causes in West Africa: Incidence and case fatality rates. Bull world health
20. Ramadani H. Caesarean section intraoperative blood loss and mode of placenta
mortality 2014;1(1):23
23. Ashraf Aly H, Hisham M Ramadani: Assessment of blood loss during caesarean section
under general anaesthesia and epidural analgesia using different methods. Alexandria J
24. Andrews W, Ramin S, Mayberry M, Shearer V. Effect of type of anaesthesia on blood
26. Duthie SJ, Gosh A, Nga Ho PC. Intraoperative blood loss during elective caesarean


APPENDIX 1

Study Title: *Comparison of visual estimation of intra-operative blood loss with hemoglobin estimation in patients undergoing caesarean section at term.*

Date……………………………………

(A) Patients Demographic Data

1. Hospital number ……………

2. Age

3. Weight

4. Gestational age

5. Indication for Caesarean Section

6. Parity

(B) Pre-anaesthetic information

1. ASA physical status

2. Mallampati score………..

3. Pre-operative vital signs…HR…SBP…..DBP……..SPO₂ ….

4. Hemoglobin level before preloading.

   Laboratory Hb………………….. Hemocue Hb (h₁)……………….

   4. Hemoglobin level (Hemocue) after preloading (hₚ)…………….
<table>
<thead>
<tr>
<th>VISUALLY ESTIMATED BLOOD LOSS</th>
<th>HB READING WITH HEMOCUE</th>
<th>HEMOCUE CALCULATED BLOOD LOSS</th>
<th>TOTAL IV FLUID GIVEN</th>
<th>PATIENT'S VITAL SIGNS (EVERY 5 MINS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PR</td>
</tr>
<tr>
<td>BEFORE SKIN INCISION</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AFTER SKIN CLOSURE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Duration of Surgery ………………………………………………………………………..

Dose of oxytocic used……………………………………………………………………

Volume of fluid given for preload……………………………………………………

Duration of preload……………………………………………………………………..

Volume of maintenance fluid given…………………………………………………

APGAR score of baby at 1, 5 and 10mins …………………………………………

Comments …………………………………………………………………………………..
PATIENT INFORMED CONSENT

To the Patient,

You have been nominated to take part in a research which is proposed to compare visual estimated blood loss with hemoglobin estimation using hemocue in patients undergoing elective caesarean section at term.

Approval for this study has been obtained from the ethical committee of the hospital.

Information/Voluntary Nature of Participation

In order to decide whether to be part of the study or not, you have to understand the study and give an informed written consent. Participation is completely voluntary and you are free to withdraw from it at any stage of the study without any consequences. There will be no additional cost to you for being part of this study.

Purpose of Study

The purpose of the study is to determine the extent of variation between visually estimated blood loss and hemoglobin estimation.

Description of Study Procedure

To enable the surgeons carry out the surgical operation (caesarean section). Regional anaesthesia (spinal anaesthesia) will be given which is the standard anaesthetic technique even for those not participating in the study, this involve injection of local anaesthetic drug into the spinal fluid through your lower back using a very fine needle.
This works by blocking the pain signals from reaching your brain. It also blocks the movement of signals to the muscles of the lower limbs which means you will be unable to move your legs while it is working. This type of anaesthesia usually works within 5-10 minutes but will last for 1-4 hours. You will be free from pain during the operation but may have strange feelings on your limbs, numbness in both lower limbs and pressure sensation around the operation site. A ‘drip’ (infusion) will be put into your vein before the injection at the back is given.

Before the drip is administered you will receive a pin prick using a sterile needle or lancet and a drop of blood will be collected to check your blood level, this pin-prick will be repeated after receiving the “drip”. Subsequently after the operation blood sample will be taken by pin-prick to enable us quantify how much blood has been lost during the surgery and to take necessary actions like giving more fluids or blood transfusion through the vein.

It may take several hours for the numbness and weakness to wear off. During this time do not attempt to walk, get someone to help you if you must do so.

**Confidentiality**

The information you give and your participation in the study will be kept confidential. If the study is published no data will reveal the individual participant.

**Benefits from the Study**

1. Result from the study will help enhance knowledge about the subject matter. This will help advance patient care which you may benefit from in the future.
2. You will enjoy the luxury of using point-of-care hemoglobin testing device called Hemocue which is known to be accurate in assessing blood loss and recommended by world health organization (WHO).

3. You will receive this treatment service during the study at no additional cost.

4. Every effort will be made to give you the best expert attention during the study.

Risks during the Study

During the research, you will not be exposed to any drugs or procedure that is not indicated, that is, this study will not expose you to any additional risk.

Feedback

In case you have any enquirys or concern regarding the research, you can contact Dr Anya Sampson U., department of anaesthesia UNTH Enugu. Nigeria. Telephone: +2348036535734

Response from the Patient

I have read the above information. I have fully understood the procedure, the benefits and risks have been well explained to me. All my doubts and worries have been clarified. I hereby give consent freely to participate in the research.

Name and Signature of Subject ................................................ Name and Signature of Researcher ........................................

Date .......................................................... Date ...........................................................

Name and Signature of Witness

Date ..........................