The American College of Obstetricians and Gynecologists
WOMEN'S HEALTH CARE PHYSICIANS

ACOG COMMITTEE OPINION

Number 794

Committee on Obstetric Practice

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Quantitative Blood Loss in Obstetric Hemorrhage

ABSTRACT: Postpartum hemorrhage causes approximately 11% of maternal deaths in the United States and is the leading cause of death that occurs on the day of birth. Importantly, 54–93% of maternal deaths due to obstetric hemorrhage may be preventable. Studies that have evaluated factors associated with identification and treatment of postpartum hemorrhage have found that imprecise health care provider estimation of actual blood loss during birth and the immediate postpartum period is a leading cause of delayed response to hemorrhage. Although current data do not support any one method of quantifying blood loss as superior to another, quantification of blood loss, such as using graduated drapes or weighing, provides a more accurate assessment of actual blood loss than visual estimation; however, the effectiveness of quantitative blood loss measurement on clinical outcomes has not been demonstrated. Successful obstetric hemorrhage bundle implementation is associated with improved outcome measures related to obstetric hemorrhage. However, further research is necessary to better evaluate the particular effect of quantitative blood loss measurement in reducing maternal hemorrhage-associated morbidity in the United States.

Recommendations and Conclusions

The American College of Obstetricians and Gynecologists makes the following recommendations and conclusions:

- Quantitative methods of measuring obstetric blood loss have been shown to be more accurate than visual estimation in determining obstetric blood loss.
- Studies that have compared visual estimation to quantitative measurement have found that visual estimation is more likely to underestimate the actual blood loss when volumes are high and overestimate when volumes are low.
- Although quantitative measurement is more accurate than visual estimation for identifying obstetric blood loss, the effectiveness of quantitative blood loss measurement on clinical outcomes has not been demonstrated.
- Implementation of quantitative assessment of blood loss includes the following two items: 1) use of direct measurement of obstetric blood loss (quantitative blood loss) and 2) protocols for collecting and reporting a cumulative record of blood loss postdelivery.
- Interprofessional protocols for the assessment of blood loss, including quantitative assessment, for both vaginal and cesarean births are best developed by a multidisciplinary team.
- Successful obstetric hemorrhage bundle implementation is associated with improved outcome measures related to obstetric hemorrhage. However, further research is necessary to better evaluate the particular effect of quantitative blood loss measurement in reducing maternal hemorrhage-associated morbidity in the United States.

Purpose

The purpose of this Committee Opinion is to review and clarify the current evidence regarding the accuracy of methods available for determining obstetric blood loss, including quantitative and visual estimated blood loss methods, and to identify research gaps. The American College of Obstetricians and Gynecologists' support for

the Alliance for Innovation on Maternal Health's Obstetric Hemorrhage Patient Safety Bundle is well established, and this document is not intended to describe how to implement the bundle. Rather, it is intended to help facilities understand the evidence that supports different approaches to measuring obstetric blood loss. Although this document offers general guidance, technicalities on how to implement blood loss measurement can be found elsewhere and is, therefore, not included here (see the For More Information section).

Introduction

Obstetric hemorrhage is a major cause of maternal morbidity (1). Postpartum hemorrhage causes approximately 11% of maternal deaths in the United States and is the leading cause of death that occurs on the day of birth (2–5). Hemorrhage that requires a blood transfusion is also the leading cause of significant maternal morbidity (4–7). Importantly, 54–93% of maternal deaths due to obstetric hemorrhage may be preventable (3, 8–10). Studies that have evaluated factors associated with identification and treatment of postpartum hemorrhage have found that imprecise health care provider estimation of actual blood loss during birth and the immediate postpartum period is a leading cause of delayed response to hemorrhage (10–13). Quantitative methods of measuring obstetric blood loss have been shown to be more accurate than visual estimation in determining obstetric blood loss (14–19). Some studies found that the use of quantitative methods resulted in a higher likelihood that women who experienced a postpartum hemorrhage were identified (15, 17, 20). However, other studies have not found that quantitative blood loss better predicts postpartum hemoglobin values (21) or changes the incidence of postpartum blood transfusion (22, 23), and thus, the effect on clinical outcomes is less clear (20).

Prevention of Postpartum Hemorrhage

Recent efforts to decrease the incidence of maternal mortality and morbidity secondary to obstetric hemorrhage have focused on development of interdisciplinary team-based protocols that facilitate early diagnosis and treatment (24, 25). The Alliance for Innovation on Maternal Health has developed an Obstetric Hemorrhage Patient Safety Bundle that is being increasingly adopted in hospitals within the United States (24–28). Quantitative and cumulative assessment of blood loss is one of several components of the Obstetric Hemorrhage Patient Safety Bundle. The California Maternal Quality Care Collaborative, regional hospital systems, and individual hospitals have reported reductions in severe maternal morbidity among patients who experience obstetric hemorrhage after implementation of this bundle, although it remains unclear whether these improvements are due to specific practices within the bundle or implementation of the bundle in total (24, 28–30).

Visual Estimation of Obstetric Blood Loss

Historically, visual estimation of blood loss during and after childbirth has been the primary method of determining obstetric blood loss. Visual estimation is subjective and imprecise (31–34). Studies that have compared visual estimation to quantitative measurement have found that visual estimation is more likely to underestimate the actual blood loss when volumes are high and overestimate when volumes are low (19, 32–36). Attempts to improve visual estimation of blood loss using visual tools for volume comparisons have been studied (32, 34). These tools have not been found to consistently improve the accuracy of visual estimation (34, 37). Although one study demonstrated improved accuracy with visual estimation of blood loss through a training program (37), a more recent study demonstrated skill decay within 9 months of training completion (34). Furthermore, visual estimation of blood loss does not appear to improve with health care provider specialty, age, or clinical experience (14, 18, 33).

Quantitative Measurement of Obstetric Blood Loss

Visual estimation has been compared to quantitative methods in both clinical and simulated scenarios (14, 17, 18, 32, 35, 36). The accuracy of blood loss assessment is improved with quantitative measurement techniques (14–16, 18, 19, 32, 36). For example, one study compared visual estimation to a gravimetric measurement in a prospective cohort study that included 150 women. In this study, blood-soaked items were weighed, and the dry weight of the items was subtracted to obtain blood loss volume. Visual estimation of blood loss compared with the gravimetric technique was associated with an error of approximately 30% (gravimetric mean blood loss was 304.1 mL versus nurse- and physician-estimated mean blood loss was 213 mL and 214.3 mL, respectively) (14).

Studies that have compared visual estimation versus quantitative methods in clinical settings have also found that quantitative methods are more likely to accurately detect postpartum hemorrhage (15–17, 38). An evaluation of low risk women after vaginal birth (n=286) conducted in Singapore found that mean estimated blood loss was 31% less accurate compared with mean measured blood loss (15). In this study the incidence of blood loss greater than 500 mL was 3.5% in the visual estimation group versus 9.1% in the direct measurement group. Only 34.6% of women with a blood loss greater than 500 mL were accurately diagnosed with visual estimation (15). Another, small study had similar findings among a cohort of low risk women after vaginal birth wherein only one woman out of eight who had a measured blood loss of greater than 500 mL was accurately identified by visual estimation (17).

Studies that used simulated blood have had similar results. One study conducted a randomized trial of

simulated vaginal delivery and compared obstetric care providers' estimation of blood loss using calibrated versus noncalibrated vaginal delivery drapes followed by crossover (18). Visual blood loss estimation with noncalibrated drapes underestimated blood loss, with worsening accuracy at larger volumes (16% error at 300 mL and 41% at 2,000 mL). The error was less than 15% at all volumes when the calibrated drape was used.

Recent developments with the use of artificial intelligence-enabled technology platforms appear promising for quantifying blood loss. These artificial intelligence platforms use mobile technology and image recognition algorithms. The tablet camera is used to take a picture of surgical sponges and canisters. The mobile app performs a colorimetric analysis, and the images are uploaded to a cloud-based machine learning program that uses algorithms to quantify hemoglobin and blood loss in real-time. One retrospective cohort study of 2,781 women demonstrated differences in estimated blood loss with an artificial intelligence-enabled platform for real time monitoring of blood loss versus traditional visual estimation for women having a cesarean birth (16). The study found that blood loss greater than 1,000 mL was more frequently detected using the artificial intelligence technology (14.1% vs 3.5% respectively; $P<.0001$), but transfusion rates were similar between the groups (16). Validation of these findings with additional research is needed.

Effect of Quantitative Blood Loss on Clinical Outcomes

Although quantitative measurement is more accurate than visual estimation for identifying obstetric blood loss, the effectiveness of quantitative blood loss measurement on clinical outcomes has not been demonstrated. Randomized controlled trials that compared visual and quantitative techniques have been performed in India and several European countries and have not found that quantitative measurement reduced the rate of severe postpartum hemorrhage (20). A recent Cochrane Review of three international trials found no difference between subjective and objective methods of assessing obstetric blood loss when comparing outcomes of serious morbidity such as need for blood transfusion (adjusted relative risk, 0.82; 95% CI, 0.46–1.46), plasma expanders (adjusted RR, 0.77; 95% CI, 0.42–1.42), or uterotonics (RR 0.87; 95% CI, 0.42–1.76) (23).

Quantitative Assessment of Obstetric Blood Loss in Obstetric Hemorrhage Bundles

Analysis of root causes in maternal mortality reviews have consistently found missed or delayed diagnosis and delay in initiating treatment are recurrent problems in care of women with excessive obstetric blood loss. Thus, addressing more accurate and timely diagnosis and treatment of postpartum hemorrhage represents an important quality improvement opportunity for prevention (10, 13, 39). Obstetric hemorrhage bundles include "measure of cumulative blood loss (formal, as quantitative as possible)" as a component. Implementation of these bundles in U.S.-based birth settings has been found to significantly reduce maternal morbidity in participating hospitals (24, 29, 30). One study reported data from the California Maternal Quality Care Collaborative state-wide hemorrhage quality improvement initiative that involved collaborative learning with hospital mentorship, rapid response data, and quality improvement support. The study used before-and-after methodology to compare outcomes from women who had an obstetric hemorrhage in hospitals that implemented an obstetric hemorrhage bundle (N=99 hospitals) versus the outcomes of women in comparison hospitals (n=48 hospitals) (24). Women who experienced an obstetric hemorrhage in the collaborative hospitals had a 20.8% reduction in severe maternal morbidity while women in comparison hospitals had a 1.2% reduction ($P<.0001$) when maternal outcomes from before the project was implemented (January 2011 to December 2014) were compared with outcomes during the last 6 months of the 18-month project (October 2015 to March 2016). In addition to state-level quality improvement initiatives, two studies from single institutions found successful hemorrhage bundle implementation was associated with a significant reduction in adverse hemorrhage-related outcomes (29, 30).

Success of quality improvement initiatives is dependent upon many factors including efficacy of the intervention, duration of the project, and extent of adoption. Reports from multihospital collaboratives have had conflicting results. Early outcome data from a study of regional hospitals working on nursing team's implementation of bundle elements did not show a reduction in hemorrhage-related severe maternal morbidity but reported that additional time was needed for implementation given no participating hospitals had yet completed implementation of the strategies (27). Additionally, a recent analysis from New York's Safe Motherhood Initiative did not show a difference in hemorrhage-related morbidity 1 year after initiation of a hemorrhage initiative (40). Conversely, a mandated implementation of an eight-component hemorrhage protocol based on the hemorrhage safety bundle that included quantitative blood loss measurement in 29 hospitals within a multistate regional health system found a significant reduction in use of blood products (−25.9% per 1,000 births, $P<.01$) when assessed 10 months after implementation of the protocol (28).

Overall, implementation of the California Maternal Quality Care Collaborative obstetric hemorrhage bundle or similar obstetric quality improvement bundle as a state-wide initiative as well as in some individual hospitals and health systems has shown successful obstetric hemorrhage bundle implementation is associated with improved outcome measures related to

obstetric hemorrhage. These outcomes may provide evidence of the effectiveness of quantitative blood loss measurement when it is included as a component of an obstetric hemorrhage bundle. However, further research is necessary to better evaluate the particular effect of quantitative blood loss measurement in reducing maternal hemorrhage-associated morbidity in the United States, as well as resources and cost-effectiveness across diverse hospital settings.

Processes for Quantification of Blood Loss

Quantification of maternal blood loss requires a team effort and can represent a cultural shift from health care provider visual estimation of blood loss to a process that involves all clinical team members at delivery, including obstetric care providers and nursing staff. Interprofessional protocols for the assessment of blood loss, including quantitative assessment, for both vaginal and cesarean births are best developed by a multidisciplinary team. Box 1 and Box 2 present example process maps for quantification of blood loss during vaginal and cesarean delivery, respectively.

Implementation of quantitative assessment of blood loss includes the following two items: 1) use of direct measurement of blood loss (quantitative blood loss) and 2) protocols for collecting and reporting a cumulative record of blood loss postdelivery (25). The process for quantification of blood loss at the time of vaginal birth is slightly different than for cesarean birth. To collect all fluids lost during a vaginal birth, a calibrated under-buttocks drape is used, whereas a calibrated suction canister is used during a cesarean birth. In both instances, the volume of fluid collected before delivery of the placenta is largely composed of amniotic fluid and urine (in the case of a vaginal delivery only) and is subtracted from the total volume of fluid collected after completion of the birth to determine the volume of blood lost during birth. Additionally, the amount of any fluid used for irrigation during either type of birth is subtracted from this volume. Finally, total cumulative blood loss in milliliters is determined by adding the weight in grams of blood-soaked materials (eg, laparotomy sponges, 4 × 4 sponges, bedsheets, disposable underpads) minus the dry weight of those materials.

There is insufficient evidence to recommend a specific timeframe to continue blood loss assessment postpartum. However, it is suggested that ongoing blood loss assessment should continue as long as active bleeding is present, or as long as the patient is unstable after a blood loss of more than 1,000 mL, including the postpartum care setting (41, 42).

The equipment needed for quantification of blood loss is easily available and includes the following items: calibrated under-buttocks drapes, laminated cards that denote dry weights for delivery items, and a scale to weigh delivery items that become blood soaked. The entire delivery care team participates in implementation of these strategies and is empowered to identify additional resources as needed for individual sites. Obstetric nurses play a critical role in tracking quantitative and cumulative blood loss. The Association of Women's Health, Obstetric and Neonatal Nurses has developed a Postpartum Hemorrhage Project toolkit with support material that includes a video on implementation of quantitative blood loss assessment for obstetric clinical care teams. High-fidelity options, such as the integration of data into the electronic medical record, are available but not necessary to accomplish quantitative and cumulative assessment of blood loss. State collaborative organizations, such as the California Maternal Quality Care Collaborative, the Florida Perinatal Quality Collaborative, and the Oklahoma Perinatal Quality Improvement

Box 1. Tips for Quantification of Blood Loss During Vaginal Delivery

Quantification of maternal blood loss is a team effort.

1. Create a list of dry weights for delivery items that may become blood soaked with directions on how to calculate blood loss.
2. Begin quantification of blood loss immediately after the infant's birth (before delivery of the placenta) and assess and record the amount of fluid collected in a calibrated under-buttocks drape. Keep in mind that most of the fluid collected before delivery of the placenta is amniotic fluid, urine, and feces. If irrigation is used, subtract the amount of irrigation from the total fluid that was collected.
3. Record the total volume of fluid collected in the under-buttocks drape.
4. Subtract the preplacental fluid volume from the post placenta fluid volume to more accurately determine the actual blood loss. Keep in mind that most of the fluid collected after the birth of the placenta is blood.
5. Add the fluid volume collected in the drapes to the blood volume measured by weighing soaked items to determine the cumulative volume of blood loss or quantification of blood loss.
6. Weigh all blood-soaked materials and clots to determine cumulative volume. *1 gram weight=1 milliliter blood loss volume.*
7. The equation* used when calculating blood loss of a blood-soaked item is WET *Item Gram Weight - DRY Item Gram Weight=Milliliters of Blood Within the Item.*

*Although a gram is a unit of mass and a milliliter is a unit of volume, the conversion from one to the other is a simple 1-to-1 conversion.

Adapted from AWHONN Practice Brief. Quantification of Blood Loss: AWHONN Practice Brief Number 1. JOGNN, 44, 158–160; 2015. DOI: 10.1111/1552-6909.1219.

Box 2. Tips for Quantification of Blood Loss During Cesarean Births

1. Begin the process of quantification of blood loss when the amniotic membranes are ruptured or after the infant is born.
2. Suction and measure all amniotic fluid within the suction canister of collected fluid before delivery of the placenta.
3. After delivery of the placenta, measure the amount of blood loss in the suction canister and drapes. At this point, most of the blood will be accounted for. Notify the team and document the amount of blood loss in milliliters.
4. Before adding irrigation fluid, ensure that the scrub team communicates when irrigation is beginning. Remember that some of the normal saline will be absorbed into the tissues. For this reason, not all the fluid will be suctioned out of the abdomen and accounted for.
5. One of two methods can be used to suction the irrigation fluid: continue to suction into the same canister and measure the amount of irrigation fluid *or* provide another suction tube to collect the irrigation separately into another canister.
6. Weigh all blood-soaked materials and clots. Calculate the weight and convert to milliliters.
7. At the end of the surgery, add the volume of quantified blood calculated by weight with the volume of quantified blood in the suction canister to determine total quantification of blood loss.
8. Note that lap pads dampened with normal saline contain minimal fluid. When they become saturated with blood, weigh them as you would a dry lap pad.

Adapted from AWHONN Practice Brief. Quantification of Blood Loss: AWHONN Practice Brief Number 1. JOGNN, 44, 158–160; 2015. DOI: 10.1111/1552-6909.1219.

Collaborative, provide free resources that can assist in the development of facility-specific protocols and policies. Please see the For More Information section for additional resources on quantitative blood loss implementation and processes.

Conclusion

Given approximately 40% of postpartum hemorrhage occurs in low-risk women, every woman giving birth is at risk for obstetric hemorrhage (25). Hemorrhage is a major contributing factor to maternal morbidity and mortality. Although current data do not support any one method of quantifying blood loss as superior to another, quantification of blood loss, such as using graduated drapes or weighing, provides a more accurate assessment of actual blood loss than visual estimation. When quantitative blood loss is included as a component of a bundle of practices that focus on prevention and early diagnosis of excessive blood loss, it may improve situational awareness and thereby improve hemorrhage diagnosis and response time.

Hospitals that participate in quality improvement activities to improve hemorrhage outcomes should monitor compliance and effectiveness of these strategies. Additional research is needed to demonstrate the effect of quantitative assessment of blood loss on clinical outcomes and whether widespread implementation of quantitative blood loss measurement strategies, either as an independent strategy or alongside other hemorrhage bundle components, will decrease maternal severe morbidity and mortality in cases of obstetric hemorrhage.

For More Information

The American College of Obstetricians and Gynecologists has identified additional resources on topics related to this document that may be helpful for ob-gyns, other health care providers, and patients. You may view these resources at www.acog.org/More-Info/QuantitativeBloodLoss.

These resources are for information only and are not meant to be comprehensive. Referral to these resources does not imply the American College of Obstetricians and Gynecologists' endorsement of the organization, the organization's website, or the content of the resource. The resources may change without notice.

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Published online on November 20, 2019.

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Quantitative blood loss in obstetric hemorrhage. ACOG Committee Opinion No. 794. American College of Obstetricians and Gynecologists. Obstet Gynecol 2019;134:e150–6.