# Quantitative Blood Loss (QBL) at every delivery: a quality improvement initiative utilizing Electronic Medical Record tools

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***Abstract***

*Maternal hemorrhage is a major cause of maternal morbidity and mortality in the United States and efforts are in place to eliminate preventable harm. Accurate assessment of blood lost around the time of birth is essential for timely recognition and intervention. As part of the Alliance for Innovation on Maternal Health (AIM) Obstetrical Hemorrhage Patient Safety Bundle at our institution a quantitative blood loss (QBL) calculator was created within the electronic medical record. This process allows for real-time tracking of cumulative blood loss measurements and is built with triggers to alert the care team when criteria for various hemorrhage stages are achieved along with suggested interventions and assessments. The consistency of implementation and efficacy of the QBL calculator was evaluated by following both utilization of the calculator flowsheet as well as tracking of rates of erroneous QBL values, defined by negative values and cesarean deliveries with QBL2019, 14 months after implementation and post three system-based improvements. By the end of this implementation review the calculator was in use consistently at all cesarean deliveries with improved confidence in the process by providers.*

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## Background

The timely diagnosis and management of postpartum hemorrhage (PPH) plays a crucial role in improving maternal safety. PPH complicates approximately 1 to 6% of deliveries in high resource nations, and 6-11% of births worldwide.[1-3] Epidemiological studies show that rates of PPH are rising in developed nations, and that PPH is the leading global cause of maternal mortality.[3,5,6] Yet, death from postpartum hemorrhage is thought to be the most

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preventable cause of maternal mortality.[7,8]

Significant hemorrhage can result in acute renal failure, cardiac arrest, disseminated intravascular coagulopathy, thrombotic emboli, and unplanned hysterectomies.[4,9] In addition, acute blood loss anemia can negatively impact mothers by increasing fatigue, stress, depression, and difficulty of mother-child interactions.[9,10] In recent years, quality improvement efforts have focused, with measurable success, on the implementation of safety bundles. Multicenter implementation of a postpartum hemorrhage safety bundle was shown to reduce severe maternal morbidity from hemorrhage by 20.8%.[9] Improved recognition of PPH through quantifying cumulative blood loss is an essential component of these safety bundles.[10]

Delays in the recognition and treatment of obstetrical hemorrhage contribute to associated morbidity and mortality.[7,8,11,12] Up to 80% of obstetrical hemorrhage is due to uterine atony[13], and atony is common immediately post-delivery. Most cases of uterine atony will resolve with fundal massage and the administration of uterotonic agents.[14] However, the expectation that bleeding will be readily controlled, coupled with an underestimation of cumulative blood loss, presents a dangerous situation where preventable morbidity and mortality may be experienced.

Historically, blood loss in excess of 500 mL for a vaginal birth and 1,000 mL for a cesarean is considered a PPH. Recently, the ACOG reVITALize initiative defined the term ‘maternal hemorrhage’ as cumulative blood loss exceeding 1000 mL or blood loss with signs or symptoms of hypovolemia within 24 hours of the birth process, with recognition that blood loss over 500 mL in a vaginal delivery is abnormal and further medical attention should be given.[10,15] Regardless of definition, precise and timely assessment of blood loss is essential to accurately diagnose and thus manage PPH. Unfortunately, studies[16] have demonstrated the inaccuracy of clinician visual estimation of blood volume, with a tendency to underestimate at higher volumes. Standardized quantification of blood loss at every delivery presents an opportunity to elevate care by ensuring that management decisions are made with the most accurate assessment of the clinical situation.

Quantitating blood loss is a logistically challenging task. The immediacy of a PPH precludes the use of hemoglobin and hematocrit. These measures do not accurately reflect rapidly changing volume status.[17] Methods of direct blood collection, including calibrated collector bags as well as gravimetric techniques, offer relative accuracy with timely results. If items are weighed using the gravimetric technique, 1 mL = 1 gr/1.06.[18] These values and weights can be entered into a quantification of blood loss calculator (QBL calculator). QBL calculators allow for automatic subtraction of washes, dry weights of various blood-saturated items, and summation of running totals. Running totals can extend to 24 hours after delivery or throughout the hospitalization, to account for delayed PPH. These tools provide near instantaneous assessment of blood loss at the time of delivery and can enhance

a clinician's awareness of the severity of an ongoing hemorrhage.

## Methods

As an initiative within the implementation of the Alliance for Innovation on Maternal Health (AIM) Obstetrical Hemorrhage Patient Safety Bundle at our institution, a QBL calculator was developed using a flowsheet within the electronic medical record (EMR). Our institution's EMR system is Epic (Epic Systems Corporation) and screenshots of the flowsheet are available from the authors upon request. The flowsheet allows for various blood-saturated items to be weighed and the calculator will subtract the predetermined dry weight of the items to give an immediate running total for blood loss. Volumes of collected amniotic fluid and wash fluid can also be recorded and will be subtracted from the total. Our workflow calls for the second nurse routinely in attendance at delivery to perform the QBL calculation process in order to keep the record as close to "real-time" as possible. All weights and measures are performed at the bedside in the delivery room or within the operating room for cesareans. Additionally, warning indicators were created using a clinical decision support tool within the EMR to alert providers and nurses to the stage of hemorrhage and the recommended evaluation and interventions. The support tool included recommendations for laboratory studies, the administration of intravenous fluids and uterotonic agents, and for the release of blood products from the blood bank based on our stage-based hemorrhage management plan. Our review and reporting on this process was waived by the Institutional Review Board as quality improvement and thus exempt.

Prior to implementation, eight live education sessions were held for nurses and providers. These education sessions were co-led by physicians and nurse project leaders. The sessions included lectures, skills stations, and simulations. While nurses are primarily responsible for making entries into the QBL flowsheet, providers were instructed on how the QBL was calculated to familiarize them with the process. The QBL calculator requires gravimetric techniques for adding sponge weights to fluid totals in calibrated collector bags. Except when accounting for amniotic fluid, a visual estimation of volume is recorded into the calculator. The universal use of the QBL calculator flowsheet on the unit began on December 1, 2017.

Erroneous values for QBL were encountered following implementation and rates were monitored. For monitoring purposes, it was determined that any negative value for QBL or any QBL total under 200 mL for a cesarean delivery was suspect for error in the calculation process and these were tracked as "QBL error". The authors recognize the limitations of these definitions and expect there were additional erroneous values that went undetected. Along with regular monitoring of QBL calculator error, data was also collected to evaluate the deliveries without blood loss recorded. This included deliveries where clinicians reverted to documentation of estimated blood loss.

During the initial 15 months of QBL calculator usage, three major process

flaws were identified, and adaptations were made to correct these. The initial issue, which was identified immediately, involved the temporal restrictions of the flowsheet format in our EMR. The calculator was not finalized until just prior to the “go-live” date and thus could not be piloted ahead of implementation. It was quickly recognized that the flowsheet only allows for data to be entered in a step-wise forward manner, and only one entry can be made per minute. This precludes the practice of retrospective documentation (“back charting”). This design feature should promote real-time bedside charting which then allows the running calculation to be used as a tool to guide clinicians’ decisions in treatment of an ongoing hemorrhage. However, the errors that occurred as a result of attempts to back chart, led to a lack of user confidence in the process. Re-education regarding the user interface of the flowsheet was initiated within a few weeks of going live with the calculator and completed by January 2018. In order to accomplish this task, department wide nursing re-education was required.

Nursing leadership was present on the unit to assess difficulties. This allowed for questions and concerns to be addressed quickly. Common themes were noted and shared at shift huddles, in newsletters and at staff meetings. The timing issues were also discussed at the interdisciplinary quality meeting. Each time there was a change in the process, nursing leadership worked to verbally share the practice change. They then reinforced the change with repetition in unit flyers, newsletters, and emails and with positive feedback.

In July 2018, due to ongoing perception by clinicians of erroneous QBL values, the process was reviewed again. A second systems process error was identified; the running total shown in the QBL calculator was found to be falsely elevated by the weight of saline used to moisten laparotomy sponges at the time of cesarean, the volume of which was not accounted for until the total volume of wash added to the surgical field was subtracted at the end of a case. This excess “wet weight” of the sponges resulted in false elevation of the running QBL total throughout the case, thus rendering the tool less useful to guide clinical decision making in real time. A change in practice was made to preferentially use dry sponges, unless moistened sponges were explicitly requested. If requested, moistened lap sponges are estimated to contain 20 mLs of sterile fluid prior to entering the body cavity. These numerical conversions were added into the calculator as needed. These changes were completed by August 2018.

In October of 2018, a comprehensive chart review of the remaining cases of QBL errors detected in August and September was performed. This identified surgical field wash fluid, as the cause of error in virtually all cesarean deliveries with QBL error. While abdominal irrigation is not standard, it can occur. The calculator was programmed to subtract the exact number of mL of wash added to the field from the recovered fluid in the suction canister total, working under the assumption that all wash added would be recovered. However, in practice we found that not all the wash could be recovered and often a significant volume

would be lost and falsely lower the final QBL. Liquid was lost on the pad underneath the patient, collected on drapes beside the patient, and was occasionally lost on the floor. In cases with below average blood loss this could result in a net negative value, or in cases with hemorrhage this could lower the final value such that the hemorrhage would go unrecognized. The realization of this cause of error in October 2018 led to the final process improvement for the QBL calculation, to eliminate the wash from the calculation process. This was piloted with scheduled cases in the month of December and widespread implementation was completed in January 2019. A review of cases from February 2019 revealed no instances of QBL error positive feedback.

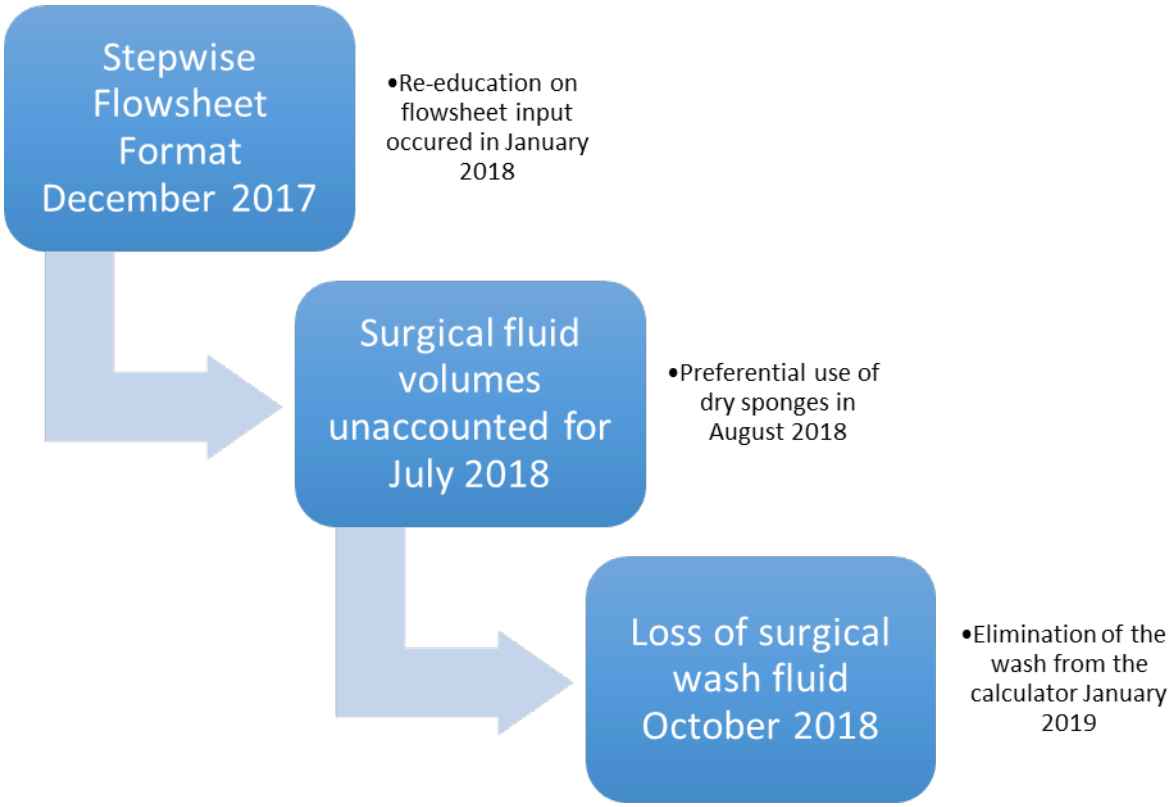


**Figure 1. Process map for improving the accuracy of the QBL calculation**

## Results

The process of implementing a QBL calculator for PPH at our institution required multiple adjustments as outlined above. The majority of these adjustments were made to compensate for issues encountered with cesarean sections, in particular the addition and recovery of fluid introduced into the surgical field. Figure 2 illustrates the QBL error rates found in cesarean deliveries vs. vaginal deliveries, and graphically highlights the effects of these complexities. After three major process changes were completed, in

January 2019, the QBL calculator error rate approached zero for both vaginal deliveries as well as cesarean sections. The error rate was zero in February 2019 for all deliveries. Table 1 shows QBL error rates over time, with a rate of 0% following the third major process change in January 2019.

Table 1 and Table 2 show use of the QBL calculator over time. Four months after project implementation all cesarean sections that occurred on the labor and delivery floor used QBL measurements. The QBL calculation is not yet used for cesarean sections performed outside of the Labor and Delivery unit, such as in the main operating room. These deliveries were excluded from the count of cesareans without calculator use in Table 1.

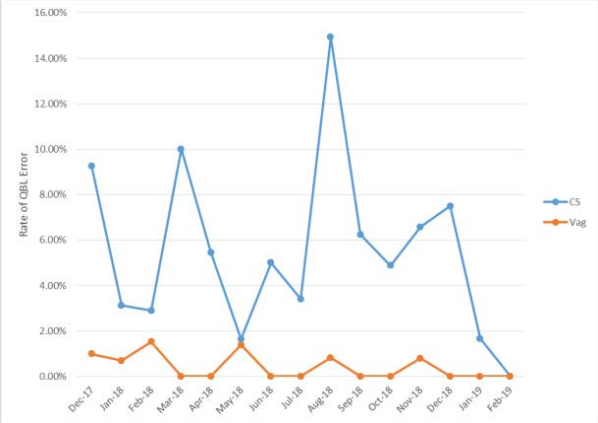


**Figure 2: Rate of QBL error observed for cesarean and vaginal deliveries**

**Table 1. Cesarean deliveries**

| Month | Total CS | CS w NEG QBL | CS w QBL <200mL | CS w/o BL recorded | CS w/out calc use | CS w/o QBL error | Rate of CS QBL error |
|---|---|---|---|---|---|---|---|
| Dec-17 | 54 | 1 | 4 | 0 | 1 | 49 | 9.26% |
| Jan-18 | 64 | 1 | 1 | 0 | 0 | 62 | 3.13% |
| Feb-18 | 69 | 0 | 2 | 0 | 0 | 67 | 2.90% |
| Mar-18 | 60 | 3 | 3 | 0 | 1 | 54 | 10.00% |
| Apr-18 | 55 | 1 | 2 | 0 | 0 | 52 | 5.45% |
| May-18 | 61 | 0 | 1 | 0 | 0 | 60 | 1.64% |
| Jun-18 | 60 | 0 | 3 | 0 | 0 | 57 | 5.00% |
| Jul-18 | 88 | 0 | 3 | 0 | 0 | 85 | 3.41% |
| Aug-18 | 67 | 3 | 7 | 0 | 0 | 57 | 14.93% |
| Sep-18 | 64 | 2 | 2 | 0 | 0 | 60 | 6.25% |
| Oct-18 | 82 | 0 | 4 | 0 | 0 | 78 | 4.88% |
| Nov-18 | 76 | 2 | 3 | 0 | 0 | 71 | 6.58% |
| Dec-18 | 80 | 1 | 5 | 0 | 0 | 74 | 7.50% |
| Jan-19 | 60 | 1 | 0 | 0 | 0 | 59 | 1.67% |
| Feb-19 | 59 | 0 | 0 | 0 | 0 | 59 | 0.00% |
| OVERALL | 999 | 15 | 40 | 0 | 2 | 944 | 5.51% |

*CS=cesarean section EBL=estimated blood loss NEG=negative BL=blood loss*

**Table 2: Vaginal deliveries**

| Month | Total Vag Del | Vag Del w NEG QBL | Vag Del w/o BL recorded | Vag Del w/out calc use | Vag Del w/o QBL error | Rate of VD QBL error |
|---|---|---|---|---|---|---|
| Dec-17 | 101 | 1 | 7 | 11 | 100 | 0.99% |
| Jan-18 | 143 | 1 | 3 | 2 | 142 | 0.70% |
| Feb-18 | 131 | 2 | 1 | 1 | 129 | 1.53% |
| Mar-18 | 144 | 0 | 9 | 8 | 144 | 0.00% |
| Apr-18 | 125 | 0 | 6 | 4 | 125 | 0.00% |
| May-18 | 144 | 2 | 9 | 2 | 142 | 1.39% |
| Jun-18 | 111 | 0 | 1 | 2 | 111 | 0.00% |
| Jul-18 | 119 | 0 | 2 | 3 | 119 | 0.00% |
| Aug-18 | 121 | 1 | 5 | 3 | 120 | 0.83% |
| Sep-18 | 124 | 0 | 3 | 3 | 124 | 0.00% |
| Oct-18 | 131 | 0 | 2 | 6 | 131 | 0.00% |
| Nov-18 | 125 | 1 | 2 | 14 | 124 | 0.80% |
| Dec-18 | 144 | 0 | 0 | 16 | 144 | 0.00% |
| Jan-19 | 128 | 0 | 0 | 14 | 128 | 0.00% |
| Feb-19 | 97 | 0 | 0 | 20 | 97 | 0.00% |
| OVERALL | 1888 | 8 | 50 | 100 | 1880 | 0.42% |

*Vag Del=vaginal delivery NEG=negative QBL= QBL calculator*

The accuracy of the calculator for vaginal deliveries was considered adequate from the time it was initiated (Figure 2). However, there was less compliance with the QBL flowsheet use for vaginal deliveries. A number of charts were individually reviewed and found to have either no blood loss recorded, or to have values for QBL/EBL recorded, but no flowsheet was used. This is graphically depicted in Figure 3.

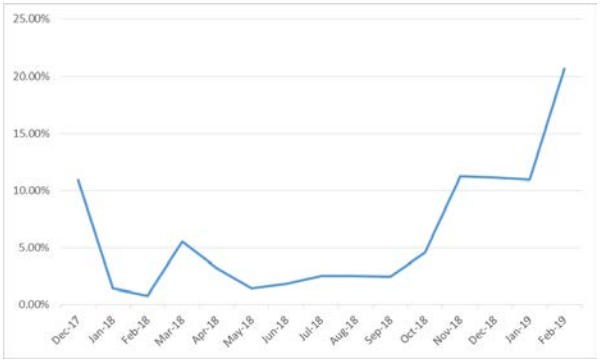


**Figure 3: Vaginal deliveries without use of QBL calculator**

Secondary endpoint data was collected to examine deliveries without blood loss recorded. This showed that vaginal deliveries were occurring for which no blood loss value was recorded in the

chart. This data is listed in Table 2 and graphically depicted in Figure 4. By December of 2018 this gap in the records had been closed and 0% of vaginal deliveries had no blood loss recorded.

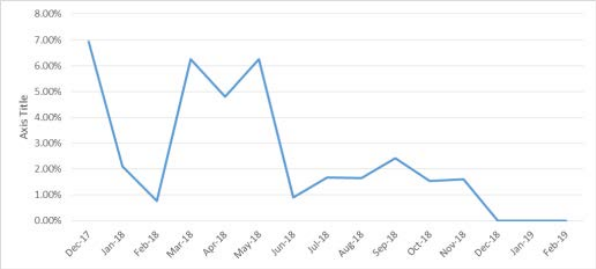


**Figure 4: Vaginal delivery without blood loss recorded**

## Discussion

The primary purpose of a QBL calculator is to augment a clinician's awareness of absolute blood loss at delivery and to allow for the timely management of PPH. Use of a flowsheet rather than a static value allows for the ability to record additional volume lost at fundal assessments or instances of hemorrhage occurring hours after delivery in one flowsheet. This QBL calculator format provides a superior mode of tracking blood loss throughout a hospitalization, and the convenience of digitally integrating the sum of the blood loss into the electronic record. Additionally, our QBL calculator is built with best practice alerts to suggest orders corresponding to best practices for stage-based hemorrhage management. The only type of loss that cannot be captured in our calculator is concealed hemorrhage, such as postoperative intraabdominal bleeding, retroperitoneal, vaginal, or vulvar hematomas, which is a limitation of any assessment of blood loss. Additionally, accurately accounting for amniotic fluid, especially when mixed with blood, is an ongoing challenge.

Despite these windows for error, we have experienced a dramatic improvement in the accuracy and ease of data collection. The integration of the calculator into our EMR for each delivery allows for automated data extraction concerning institution wide hemorrhage rates and maternal outcomes. This will allow for assessment of the effect of implementing the AIM bundle of PPH intervention on patient care outcomes and comparison of trends within the institution over time.

An important note for discussion in the development of this project is the unintended, but significant, consequence of increasing the deliveries for which no blood loss was recorded (shown in Figure 4). Due to supplementary data collection, this review was able to capture this unanticipated outcome of QBL calculator. Prior to the development of the QBL calculator, our EMR had required the entry of an estimated blood loss in order to sign a delivery record. With the conversion from EBL to QBL this required action in the delivery summary was lost. An unforeseen decline in documentation of blood loss may have resulted in an inferior quality of care. This serves as an example of the importance of collecting ancillary data and reviewing all quality safety initiatives within a broad context. This oversight was recognized and a new requirement for recording QBL has been implemented. Follow up on rates of

unrecorded blood loss presents an opportunity for further investigation.

One limitation of our study is that there was not measure of provider acceptability of the new process. Accurate accounting of amniotic fluid in particular requires attention by the delivery provider to this volume, which may interfere with the immediate clinical care of delivery. Weighing of items for the QBL is an additional task for the nursing staff. Future works regarding process implementation may benefit from assessing provider experience and comfort with new approaches.

It is worth recognizing that recent publications have highlighted limitations of the clinical utility of QBL to predict change in hemoglobin or need for transfusion, indicating that QBL is not a perfect process or solution.[19,20] The authors would argue that prior works demonstrating the inaccuracy of estimation and the dangers of delay in hemorrhage management greatly outweigh the limitations of QBL. Best practices for transfusion indicate decisions should incorporate real-time measures of hemodynamic stability, such as the vital signs, urine output, and patient's mental status. There is not a clear threshold of blood loss that determines need for transfusion and QBL should not be construed to indicate such a value exists.

The QBL calculator is a valuable tool that allows for blood loss quantification. It can increase awareness, urgency, and accuracy in the diagnosis of PPH. While the calculation of blood loss is objective, process errors can occur. All calculated totals should be evaluated in the context of the clinical situation and the provider's judgment.

The QBL calculator could be used at other institutions to improve maternal outcomes in the case of PPH by providing more immediate and accurate information about blood loss. In addition, the use of this calculator could be expanded beyond obstetric hemorrhage to other areas of medicine. Modifications of our process could be made to create a QBL calculator with prompts for standardized orders, such as obtaining lab studies and the release of blood products, for use in other high blood loss situations such trauma surgeries or emergency rooms.

## Conclusion

In December 2017, a QBL calculator using flowsheet functionality within the EMR was implemented on our Labor and Delivery unit. This allows for real-time data to be used in the management of post-partum hemorrhages. This new tool required several refinements in order to reduce the rate of errors in QBL calculations. With continuous monitoring and implementation of changes, process error with QBL reached zero for all deliveries in February 2019.

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