Comprehensive maternal hemorrhage protocols improve patient safety and reduce utilization of blood products

Laurence E. Shields, MD; Kathy Smalarz, RN; Lester Reffigee, MD; Sandra Mugg, RN; Theodore J. Burdumy, MD; Marilyn Propst, RN

OBJECTIVE: The purpose of this study was to assess the effectiveness of instituting a comprehensive protocol for the treatment of maternal hemorrhage.

STUDY DESIGN: The protocol was separated into 4 stages, designated 0-3, based on the degree of blood loss and the patient response to interventions. Key components included admission risk assessment, measurement of blood loss, early but limited use of uterotonic agents, early presence of obstetrical and anesthesia staff, and transfusion with fixed ratios of blood products. Data were collected retrospectively and prospectively relative to the start of the protocol.

RESULTS: We noted a significant shift toward resolution of maternal bleeding at an earlier stage ($P < .01$), use of fewer blood products ($P < .01$), and a 64% reduction in the rate of disseminated intravascular coagulation. In addition, there were significant improvements in staff and physician perceptions of patient safety ($P < .01$).

CONCLUSION: Comprehensive maternal hemorrhage treatment protocols improve patient safety and reduce utilization of blood products.

Key words: comprehensive, maternal hemorrhage, patient safety, protocol

Cite this article as: Shields LE, Smalarz K, Reffigee L, et al. Comprehensive maternal hemorrhage protocols improve patient safety and reduce utilization of blood products. Am J Obstet Gynecol 2011;205:368.e1-8.

Maternal hemorrhage remains a major source of maternal morbidity and mortality in both developed and underdeveloped countries.[1] Nationwide, the rate of postpartum hemorrhage from 1995 through 2004 has steadily risen, and in 2004 approximately 3% of all births were complicated by postpartum hemorrhage.[2,3] The nationwide rate of transfusion during admission for labor and delivery nearly doubled during the 8-year period from 1997 through 2005.[3,4] Similar trends from 1991 through 2004 have been noted in Canada, Australia, and Europe.[5] This increased need for transfusion in the peripartum period has been attributed to many factors. Although significant concerns have been raised regarding abnormal placentation,[6,7] the increased rate of transfusion has been primarily related to increased rates of uterine atony[2,3,5,8] and can only partially be explained by changes in obstetrical practice.[3] Although most patients respond to therapy, "near miss" events, defined as blood loss of ≥1500 mL, occur in about 15% of patients experiencing postpartum hemorrhage.[9] These data suggest that approximately 18,000 women per year in the United States have life-threatening hemorrhage during the course of childbirth.

Obstetricians, anesthesiologists, and obstetrical nurses all have experience with treatment of obstetrical hemorrhage. However, the frequency at which any one provider will be faced with significant obstetrical bleeding is low, suggesting that standardized and coordinated intervention is critical for optimal maternal and neonatal outcome.[10,11] Active vs expectant management in the third stage of labor has been shown to decrease the risk for postpartum hemorrhage. If bleeding continues, then consistent and aggressive management of the postpartum period has been shown to reduce the severity of maternal hemorrhage.[10,12] Recently the Joint Commission recommended the adoption of protocols to address maternal mortality and morbidity associated with postpartum hemorrhage.[13]

In 2008, we instituted a hospitalwide comprehensive patient safety initiative that was directed specifically at the treatment of maternal hemorrhage. This was designed to facilitate coordination between all hospital personnel and ancillary services that would potentially be involved with treating patients with maternal hemorrhage. The objective of this study was to assess 2 key components of this policy. First, did institution of the hemorrhage protocol reduce the severity of obstetric hemorrhage? Second, did early intervention reduce the number of patients requiring transfusion or the number of units (U) transfused?

Materials and Methods

Collection of data for this study was approved as part of an ongoing clinical patient safety monitoring program and as

From the Departments of Obstetrics and Gynecology (Dr Shields) and Anesthesia (Dr Burdumy), Marian Medical Center, Catholic Healthcare West (Ms Smalarz, Ms Mugg, and Ms Propst), and the Santa Barbara County Public Health Department (Dr Reffigee), Santa Maria, CA.

Received March 9, 2011; revised May 2, 2011; accepted June 22, 2011.

The authors report no conflict of interest.

Presented at the 31st annual meeting of the Society for Maternal-Fetal Medicine, San Francisco, CA, Feb. 7-12, 2011.

Reprints not available from the authors.

0002-9378/free

doi: 10.1016/j.ajog.2011.06.084

For Editors' Commentary, see Table of Contents

TABLE 1
Admission risk assessment

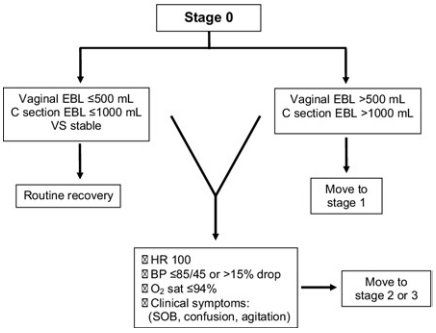
Low risk (clot-to-hold)	Medium risk (type and screen)	High risk (cross-matched and blood bank alert)[a]
• Unscarred uterus • No Hx of postpartum hemorrhage • ≤4 previous vaginal deliveries • Singleton pregnancy	• Prior uterine surgery • Hx of postpartum hemorrhage • ≥4 previous vaginal deliveries • Multiple gestation • Large uterine fibroids • Chorioamnionitis • Magnesium sulfate use • Positive antibodies on antepartum screen	• Previa/accreta • Hematocrit <30% with other risk factor • Bleeding on admission • Coagulation defect • Platelets <100,000

Hx, history.

[a] Depending on factors involved, larger numbers of blood products may be prepared.

Shields. Maternal hemorrhage protocol. Am J Obstet Gynecol 2011.

FIGURE 1
Protocol algorithm for stage 0



In event of bleeding beyond expected as normal or abnormal maternal vital signs were present, patient's status was elevated to higher level of care.

EBL, estimated blood loss; *IV*, intravenous; *MD*, physician; *RN*, nurse.

Shields. Maternal hemorrhage protocol. Am J Obstet Gynecol 2011.

part of an approved hospital continuous quality improvement program.

There were 3 main phases of preparation prior to protocol initiation: development, education, and team training/simulation. Protocol development, November 2008 through January 2009, was designed to optimize prompt action from health care providers and clinical services, as well as a system that facilitated communication between health care providers and ancillary services (diagnostic laboratories and blood bank).[9,10,12,14,15] After development and designation of the hemorrhage stages, an educational phase was carried out from February 2009 through April 2009. At this time, adjustments and modifications were suggested and adopted by the different groups that were going to participate in the protocol. Nursing personnel also had blood loss skills training.[16-18] Finally, labor and delivery simulations were carried out. These were designed to enable each member of the team to practice their role and to determine how the different aspects of the protocol are integrated.[19] After this was accomplished, the protocol was officially launched in May 2009.

The overall goal of the protocol was to facilitate early intervention, early treatment with blood products, and reduce the incidence of disseminated intravascular coagulation (DIC). Key elements of the protocol were graded assessments of patient acuity and standardization of interventions. The patient's status and the interventions were grouped into 4 categories (stages 0-3). The protocol was initiated at the time of admission to labor and delivery. At that time, an initial risk assessment was made related to patient's potential risk for obstetrical hemorrhage (Table 1).[2,20,21] Patients were then categorized as low, medium, or high risk. Based on the admission risk assessment, different levels of "status alerts" were given to the blood bank. Patients initially assessed as low risk had a request for a clot-tube to be held in blood bank. Medium-risk patients had a "type and screen" carried out, and those patients who were deemed high risk had cross-matched blood prepared. The patient's risk status could change during the course of her labor and delivery. This process was done primarily to streamline rapid access to blood products when needed.

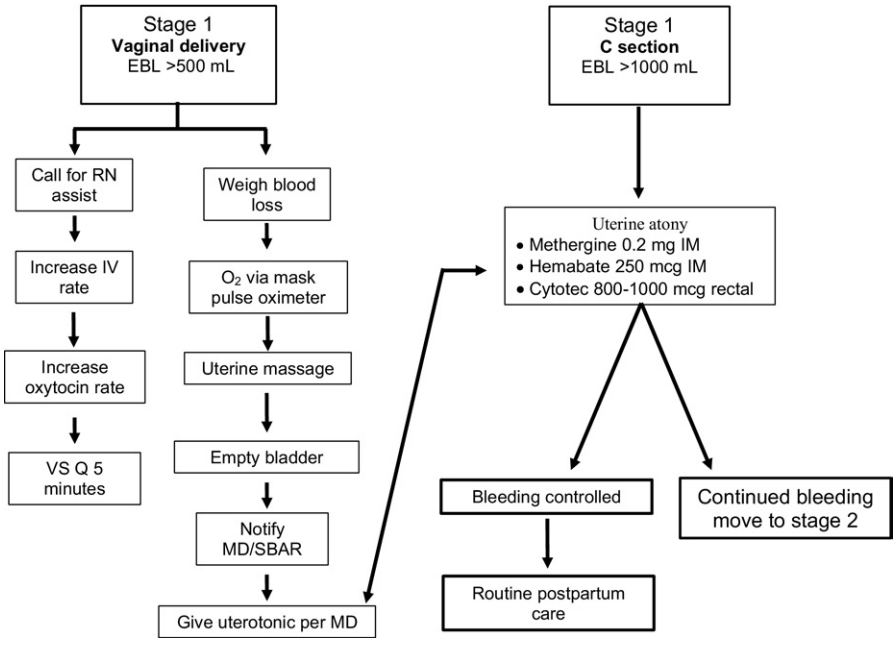
Although patient status was assessed in both the intrapartum and postpartum time periods, protocol interventions were primarily designed to address postpartum hemorrhage interventions. The bleeding status of each patient was continuously assessed and assigned a clinical hemorrhage stage. Stage 0 was designated as a normal intrapartum and postpartum course. Stage 1 was defined as bleeding greater than expected for normal vaginal delivery (500 mL) or cesarean section (1000 mL).[22] Stage 2 was defined as bleeding not responding to conservative treatment outlined in stage 1, and stage 3 was defined as continued bleeding with actual or expected blood loss >1500 mL. Additional details of each stage are outlined in Figures 1-4.

Due to recognized inaccuracies in blood loss estimates even after training,[16] measurement of blood loss was assessed by weighing all lap sponges, bedware if needed, and fluid in collection systems.[23] Nonblood fluid in delivery collection systems, particularly prior to delivery of the placenta, was subtracted from the estimated blood loss. Although there is some risk that there will be amniotic fluid included in the blood loss estimate, this method has been shown to improve the accuracy of blood loss.[18,24] After delivery, bedding was changed to eliminate the risk of amniotic fluid contamination from that point forward. Aberrations of maternal vital signs (sustained heart rate >100 bpm, blood pressure <85/45 mmHg, or patient symptoms [shortness of breath, confusion, or agitation]) were deemed significant enough to warrant a higher-level care.[13] At any time during the course of care, symptoms or aberrations of vital signs caused patient care status to be elevated to either stage 2 or stage 3.

Patients activated to stage 1 after vaginal delivery were primarily treated by nursing personnel. Uterine atony remains the most common cause of postpartum hemorrhage,[2,3,8] and this stage was designed primarily for prompt assessment and treatment of uterine atony. If uterine atony was suspected, a single dose of an uterotonic could be given after discussion with the physician. Additional aspects of stage 1 care are noted in Figure 2. If there was a need for a second dose of an uterotonic agent, the patient's status was upgraded to stage 2. A similar approach to the treatment of uterine atony at cesarean section was used, and patients not responding to oxytocin infusion and an uterotonic were elevated to stage 2. The details of stage 2 are outlined in Figure 3 (vaginal delivery and cesarean section).

The most significant component of stage 2 was a commitment of additional personnel assigned to the patient's care. This included the addition of a second nurse and notification of the on-call nursing supervisor to facilitate assignment of additional nursing and operating room support as needed. The second major component of stage 2 for vaginal deliveries was that both the patient's obstetrician and the on-call anesthesiologist were required to report to the patient's bedside, or the operating room if the treating nurse believed that the patient would be better served in that location. This requirement was believed to be critical and designed to prevent continued use of therapies that were either ineffective or would limit timely physician evaluation and treatment. It was hoped that aggressive intervention at this stage would limit the number of patients who went on to experience life-threatening hemorrhage and/or DIC.[9,10,12] To facilitate treatment, an "obstetrical hemorrhage cart" was created and assigned to both labor and delivery and the main operating room. The hemorrhage cart was designed and organized to have all of the routine and unique supplies that would be necessary for patient management. At stage 2, the hemorrhage cart was brought to the patient's room. The specific items of the hemorrhage cart are outlined in Table 2.

FIGURE 2
Protocol algorithm for stage 1



In event of bleeding after stage 0 care, additional support was given to patient and, after conferring with physician, single dose of supplemental uterotonic was given if atony was suspected.

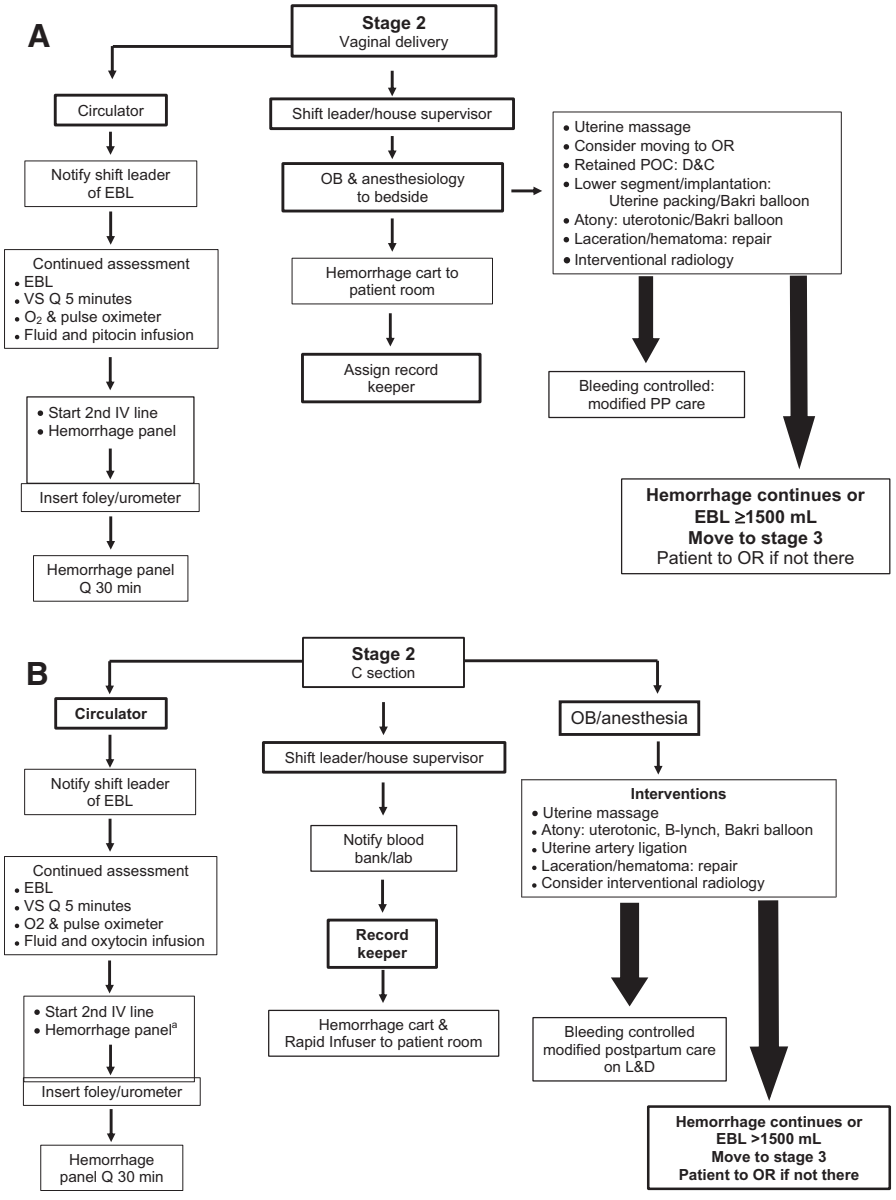
EBL, estimated blood loss; *IV*, intravenous; *MD*, physician; *O_2*, oxygen; *RN*, nurse; *SBAR*, Situation-Background-Assessment-Recommendation; *VS*, vital signs.

Shields. Maternal hemorrhage protocol. Am J Obstet Gynecol 2011.

If the estimated blood loss was at or expected to be >1500 mL, the patient's status was elevated to stage 3 (Figure 4). The primary goal of stage 3 was to mobilize and orchestrate all available resources toward reducing further blood loss or development of DIC. Additional nursing support was assigned, and considerations for additional physician support (obstetrical, anesthesia, general or urologic surgeons, and interventional radiology) were also suggested. At this point, fixed ratios of blood products in a designated "obstetrical hemorrhage pack" were prepared for immediate release from the blood bank. The maternal hemorrhage pack included 3 U of packed red blood cells, 2 U of fresh frozen plasma, 1 pheresis U of platelets, and 10 U of cryoprecipitate. Blood (packed red blood cells) and fresh frozen plasma were given in fixed ratios of 3:2.[14,25] This ratio was increased to 1:1 after the transfusion of the first 6 U of packed red blood cells and 4 U of fresh frozen plasma, as this combination has been shown to improve survival in trauma-related hemorrhage.[26-28] Treatment was directed toward the goal of maintaining the hematocrit >24%, international normalized ratio <1.4, platelet count >50,000/uL, and fibrinogen >100,000 mg/dL. Additional goals included maintaining the patient's pH >7.2, base excess >–5, temperature >95°F (35°C), and a normal ionized calcium as all of these factors are known to influence coagulation.

Because patients activated to either stage 2 or 3 had postpartum courses that were not normal, they were assigned to receive modified postpartum surveillance. Postpartum care was continued on labor and delivery for 24 hours for patients successfully treated at stage 2. Laboratory studies were repeated at 1 and 4 hours and vital signs, including urine output, were repeated at higher frequencies for the first 6 hours after bleeding normalized. Patients who were treated at a stage 3 level were all initially monitored in the intensive care unit in

FIGURE 3
Protocol algorithm for stage 2



A, Vaginal delivery. **B,** Cesarean section. Key components of stage 2 were additional support personnel and **A**, presence of obstetrician and anesthesiologist to patient's bedside. OB hemorrhage cart was also brought to **A**, patient's bedside or **B**, OR to facilitate other potential interventions. Patients reaching this level of care also had modified postpartum care.

CBC, complete blood count; *EBL*, estimated blood loss; *IV*, intravenous; *L&D*, labor and delivery; *OB*, obstetrical; *OR*, operating room; *POC*, products of conception; *PT*, prothrombin time; *PTT*, partial thromboplastin time; *VS*, vital signs.

[a]Hemorrhage panel: CBC with platelet count, PT, PTT, fibrinogen, electrolytes and creatinine. *Bold boxes* represent personnel with specific assignments.

Shields. Maternal hemorrhage protocol. Am J Obstet Gynecol 2011.

cooperation with critical care, anesthesia, and obstetrics. In some cases where deemed appropriate, and after discussion with the intensivist, care would be carried out on labor and delivery. The rationale for intensive care unit admission was primarily based on concerns related to development of pulmonary edema and renal compromise. The minimal frequency and duration of vital signs and laboratory assessments was outlined by the protocol.

The primary goal of the protocol outlined here was to address the clinical problem of maternal hemorrhage, as well as improve overall patient safety. To determine if hospital personnel and physicians thought that the implementation of the hemorrhage protocol improved patient care, patient safety, and the ability to respond to maternal hemorrhage, a survey was sent to treating physicians (obstetricians and anesthesiologists) and nursing staff. The survey was given 1 year after initiation of the protocol. The survey questions for nursing and physicians are noted in Table 3. The responses were evaluated using a 5-point system.

For data analysis, the time period prior to and after implementation of the hemorrhage protocol were compared. To address the question of whether we reduced the severity of hemorrhage, we compared the number of patients who were activated to each stage of the protocol in the control period vs the intervention period. The control period was 4 months in duration (985 deliveries), and interventional time was 12 months divided into 3 different 4-month blocks (2874 deliveries). These time blocks were chosen, because we had established clearly defined hemorrhage stages and data could be prospectively collected. Data were analyzed by analysis of variance for changes in the number of patients treated at each stage. Our second question asked whether aggressive management and a liberal use of replacement blood products reduced the total units of blood transfused on the obstetrical service. Data on the number of patients receiving blood products and the number of units transfused were collected from the blood bank. We compared the 12-month time period prior to protocol initiation and pretraining (preprotocol, 2939 deliveries) and the 12 months after the hemorrhage protocol was initiated (postprotocol, 2874 deliveries). Data were analyzed by *t* test. Finally, survey results comparing hospital staff and physician perceptions prior to and after initiation of the hemorrhage protocol were compared by paired *t* test.

Results

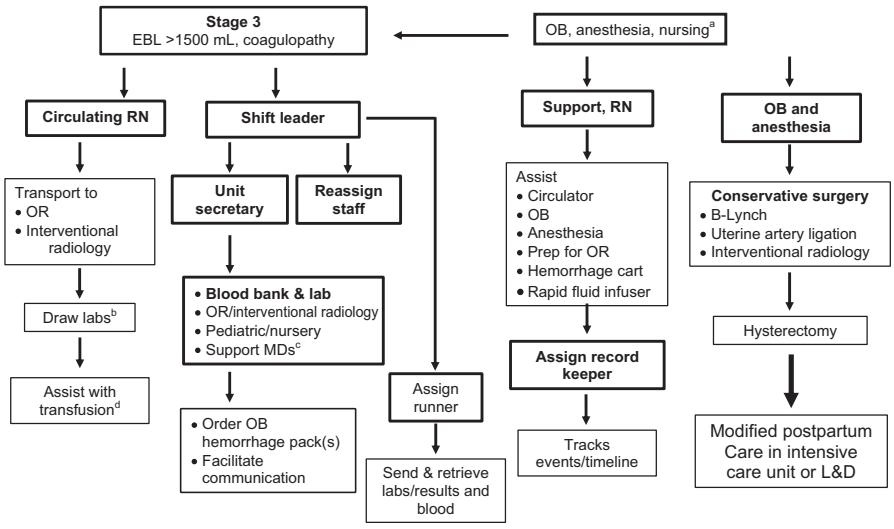
During the study period there were 5813 deliveries. The overall maternal hemorrhage rate (stages 1-3) was 3.6%. The hemorrhage rate for the combination of stage 2 (ie, defined as required more than a single dose of a uterotonic) and stage 3 (bleeding >1500 mL) was 1.5%.

During duration of the study, the total number of patients treated at either stage 1 *or* stage 2 did not differ between the preprotocol and postprotocol time periods. However, after protocol implementation, there was a significant shift in the percentage of patients who were successfully treated at the stage 1 level. Prior to initiation of hospitalwide training, only a third of patients were successfully treated at stage 1, and just >50% of patients required stage 2 level interventions. After training and protocol initiation, this changed, and 82% were successfully treated at stage 1 ($P = .02$, $R^2 = 0.95$) and only 8% of patients reached stage 2 ($P = .02$, $R^2 = 0.97$) (Table 4). Thus, consistent with the goals of the protocol, we noted that training and protocol initiation was associated with a significant shift toward patients requiring less intervention and successfully being treated at a lower acuity level.

Of patients categorized as having any blood loss greater than expected (stages 1-3), 10% fell into the severe category, or stage 3. The percentage of patients requiring stage 3 intervention did not change during the duration of the study. However, other indirect goals of the protocol were that early intervention would ultimately reduce the number of units of blood products used and there would be a reduction that the number of patients treated for DIC. We compared the utilization of blood products in the 12 months prior to initiation of the protocol to the 12 months after the protocol was in place. We noted a significant reduction in the total number of blood products transfused and the average number of blood products used per month (16.7 units/month preprotocol and 6.3 units/month postprotocol, $P <$ .01). This was primarily a result of significantly less DIC noted in the 12-month postprotocol time period, where the rate of DIC was reduced by 64% ($P = .06$).

One year after the initiation of the hemorrhage protocol, hospital staff and physicians were surveyed to determine if they thought the protocol improved patient care, patient safety, their ability to respond to maternal hemorrhage, and the effectiveness of team communication. The survey was returned by 61% of the physicians and 32% of the nursing staff. There was a significant shift from lower levels of comfort to being mostly comfortable/confident in hemorrhage situations, as well as in team communication (physicians [$P < .01$] and nursing staff [$P < .01$]). These data suggest that physicians and hospital staff favorably viewed the initiation of the protocol with regard to their own ability to respond to a maternal hemorrhage and that this created a culture of improved patient care.

FIGURE 4
Protocol algorithm for stage 3



Stage 3 designation was given when EBL was expected to be or was >1500 mL or presence of disseminated intravascular coagulation. Key components of stage 3 were assignment of additional support personnel, coordination among OB unit, operating room, blood bank, and laboratory. When stage 3 was reached, blood bank was immediately notified and prepared fixed ratios of blood products for transfusion. Stage 3 patients had modified postpartum care.

CBC, complete blood count; *EBL*, estimated blood loss; *INR*, international normalized ratio; *L&D*, labor and delivery; *MD*, physician; *OB*, obstetrical; *OR*, operating room; *PT*, prothrombin time; *PTT*, partial thromboplastin time; *RN*, nurse.

[a]Stage 3 could be activated by attending obstetrician, anesthesia, or the treating nurse; [b]Labs include CBC with platelet count, PTT, PT, fibrinogin, chemistry panel, ionized calcium, pH and blood gases; [c]Support MDs include general surgery, urology, second obstetrician or anesthesiologist as deemed necessary; [d]The goal of transfusion was to maintain hematocrit >24%, INR <1.4, platelet count >50,000/uL, and fibrinogen >100,000 mg/dL.

Shields. Maternal hemorrhage protocol. Am J Obstet Gynecol 2011.

Comment

The primary goal of this study was to assess the effect of initiating a comprehensive protocol for the treatment of postpartum hemorrhage. Consistent with the goals of the protocol, we noted 4 important outcomes. First, patients were successfully treated at a lower stage or degree of hemorrhage and thus experienced less overall blood loss. This allowed care to be maintained at a lower acuity level. Second, we demonstrated that even in the background of promoting early intervention with blood products, fewer blood products were given to patients. This not only reduces the risk for blood-borne illness, but also reduces the burden of obstetrical hemorrhage on local blood banks. Third, early intervention resulted in fewer patients experiencing life-threatening DIC. Fourth, both physicians and nursing staff reported improved clinical knowledge and improved comfort levels when responding

TABLE 2
Components of obstetrical hemorrhage cart

Drawer	Contents
Top of cart	Laminated copy of hemorrhage protocol algorithm, cart item checklist for items stocked in each drawer, surgical consent forms, key telephone numbers, nonsterile gloves
Drawer 1	IV start kits, IV tubing and extension, angiocatheters, tape, alcohol swabs, blood filters, blood gas/pH kits
Drawer 2	Blood tubing, normal saline, lactated ringers, hetastarch
Drawer 3	Hemorrhage timeline record, uterotonic chart, diagrams of B-lynch or O'Leary suture techniques and sutures for B-lynch, blood collection tubes for coagulation, CBC, chemistry studies, tourniquets, vacutainers, syringes
Drawer 4	Obstetric procedure/laceration tray, standard and weighted speculums, large curette, vaginal packing supplies
Drawer 5	Arterial line supplies, large-bore triple lumen kit, stopcocks, IV pressure bag and supplies, sterile gloves
Drawer 6	Bakri uterine tamponade balloon and instructions (Cook Medical, Bloomington, IN), rapid infusion and fluid warmer supplies, Foley catheter, surgical drains, Bair Hugger upper body blanket (Arizant Healthcare Inc., Prairie, MN)
Adjacent to cart	Postpartum hysterectomy tray
Obstetrical hemorrhage cart	Hemorrhage cart was designed and organized to contain all routine and unique supplies that would be necessary for patient management; 2 carts were available, first in labor and delivery and second in main hospital operating room area

CBC, complete blood cell count; *IV*, intravenous.

Shields. Maternal hemorrhage protocol. Am J Obstet Gynecol 2011.

TABLE 3
Questions used to survey physicians and nursing personnel

Questions were asked in reference to perceptions prior to and after implementation of hemorrhage protocol

Questions for all personnel:
1. How well were you prepared for assessing blood loss?
2. How well were you prepared to handle obstetrical hemorrhage?
3. How well did ancillary services (laboratory, blood bank, and staff) respond to your needs during hemorrhage?

Additional questions for physicians:
4. How well did nursing respond to obstetrical hemorrhage?
5. How well did operating room team respond to obstetrical hemorrhage?
6. How well does obstetrical/anesthesia team respond to obstetrical hemorrhage?

Additional questions for nurses:
4. How comfortable were you with calling physician when you were uncomfortable with your assessment of estimated blood loss or patient's status?
5. How well did physicians respond to your concerns?
6. How well did operating room team respond to obstetrical hemorrhage?
7. How effective was patient care "hand-off communication" between different hospital units?

Shields. Maternal hemorrhage protocol. Am J Obstet Gynecol 2011.

to a maternal hemorrhage. There was uniform agreement that patient care and patient safety were improved.

The results of this study are consistent with the recent Joint Commission Sentinel Alert[13] that recommended adoption of protocols to address maternal mortality and morbidity associated with hemorrhage. Two states (New York and Illinois) have mandated training directed toward treatment for maternal hemorrhage, and recently California developed a comprehensive protocol to address maternal hemorrhage.[29] Excellent Web-based resources are available from both the New York (http://www.health.state.ny.us/professionals/protocols_and_guidelines/maternal_hemorrhage/) and California (http://www.cmqcc.org/ob_hemorrhage) programs. The protocol presented here, and from the California Maternal Quality Care Collaborative, was designed to produce earlier intervention, on-site presence of physician personnel, and prevention of repeated use of unsuccessful interventions. There are very few published data regarding the impact of these interventional programs. Rizvi et al[12] from Ireland reported their results after instituting a labor and delivery hemorrhage policy that included staff education and has many elements that are similar to our stage 1 response. They noted a reduction in the rate of transfusion and were able to demonstrate a reduction in the rate of uterine atony, need for transfusion, and peripartum hysterectomy, and a significant reduction in severe hemorrhage (blood loss of >1500 mL). The major limitation of their study and ours is the relatively small number of deliveries reported. Hopefully, outcome data from other larger patient datasets will be presented and will show similar reductions in blood resource utilization and rates of DIC. If the data presented here and from others[12] were reproduced nationally, there would be a 60% reduction in blood product utilization and similar reduction in the number of patients experiencing DIC as part of childbirth.

The hemorrhage protocol reported here was initiated in a medium-sized, rural facility with slightly less than 3000 deliveries per year. The hospital is part of a larger hospital system with 33 obstetrical facilities and a total delivery service of about 80,000 per year. The obstetrical services in this hospital system vary in size, from a low of about 300 deliveries per year with other facilities having >5000 deliveries per year. At the time this protocol was developed, some type of hemorrhage protocol was in use at all of the hospitals with >3000 deliveries per year. Of the hospitals with services <3000 deliveries per year, only 6 of 21 centers (28%) had a hemorrhage proto-

TABLE 4
Changes in stage of hemorrhage before and after protocol initiation

Stage	Preprotocol	Post-period 1	Post-period 4	Post-period 3
1[a]	35% (22)[b]	51% (25)	69% (27)	82% (49)
2[a]	53% (33)	45% (22)	18% (7)	8% (5)
3	11% (7)	4% (2)	13% (5)	10% (6)

[a] $P = .02$; [b] Numbers in parenthesis are total patients at that stage in that time period.

Shields. Maternal hemorrhage protocol. Am J Obstet Gynecol 2011.

col in place. After initial development, the protocol outlined here was subsequently rolled out to all of the hospitals with obstetrical delivery services within the Catholic Healthcare West system. Each individual hospital made modifications to meet local staffing needs.[10] In smaller facilities, personnel needs are met through "cross-trained" on-site rapid response teams. Thus, although the algorithms used here were designed in a medium-sized hospital, the overall theme was easily transferred and adopted in a large hospital system where delivery service size varies considerably.

Both physicians and nursing staff reported improved clinical knowledge and an improved comfort level when responding to a maternal hemorrhage after education and protocol adoption. More importantly, there was near uniform agreement among all surveyed that patient care and patient safety were improved after the initiation of the hemorrhage protocol outlined in this report. Although not directly measured, the success of this hospitalwide approach of maternal hemorrhage has facilitated the institution of other patient safety initiatives. We hope that other institutions will take the data presented here, along with the resources that are readily available from other online sources,[21,29] and produce a hemorrhage response system that will be tailored to their facility. Based on the success of the system presented here and reported elsewhere,[12,19,29-32] the primary goals of those endeavors should include (1) a system that enhances communication between all members of the treatment team; (2) staff education and input regarding protocol development; (3) blood loss assessment training; (4) early standardized treatment and prevention of repeated use of ineffective treatment; (5) early requirement for physician (obstetric and anesthesia) presence; and (6) early intervention with fixed ratios of blood products. These recommendations should facilitate staff and physician acceptance and have been proven to be essential elements of effective interventions. ■

REFERENCES

1. Khan KS, Wojdyla D, Say L, Gulmezoglu AM, Van Look PF. WHO analysis of causes of maternal death: a systematic review. Lancet 2006;367:1066-74.

2. Bateman BT, Berman MF, Riley LE, Leffert LR. The epidemiology of postpartum hemorrhage in a large, nationwide sample of deliveries. Anesth Analg 2010;110:1368-73.

3. Callaghan WM, Kuklina EV, Berg CJ. Trends in postpartum hemorrhage: United States, 1994-2006. Am J Obstet Gynecol 2010;202:353.e1-6.

4. Kuklina EV, Meikle SF, Jamieson DJ, et al. Severe obstetric morbidity in the United States: 1998-2005. Obstet Gynecol 2009;113:293-9.

5. Knight M, Callaghan WM, Berg C, et al. Trends in postpartum hemorrhage in high resource countries: a review and recommendations from the International Postpartum Hemorrhage Collaborative Group. BMC Pregnancy Childbirth 2009;9:55.

6. Flood KM, Said S, Geary M, Robson M, Fitzpatrick C, Malone FD. Changing trends in peripartum hysterectomy over the last 4 decades. Am J Obstet Gynecol 2009;200:632.e1-6.

7. Wu S, Kocherginsky M, Hibbard JU. Abnormal placentation: twenty-year analysis. Am J Obstet Gynecol 2005;192:1458-61.

8. Joseph KS, Rouleau J, Kramer MS, Young DC, Liston RM, Baskett TF. Investigation of an increase in postpartum hemorrhage in Canada. BJOG 2007;114:751-9.

9. Sheikh L, Zuberi NF, Riaz R, Rizvi JH. Massive primary postpartum hemorrhage: setting up standards of care. J Pak Med Assoc 2006;56:26-31.

10. Stainsby D, MacLennan S, Hamilton PJ. Management of massive blood loss: a template guideline. Br J Anaesth 2000;85:487-91.

11. Leduc D, Senikas V, Lalonde A. Active management of the third stage of labor: prevention and treatment of postpartum hemorrhage. J Obstet Gynaecol Can 2009;235:980-93.

12. Rizvi F, Mackey R, Barrett T, McKenna P, Geary M. Successful reduction of massive postpartum hemorrhage by use of guidelines and staff education. BJOG 2004;111:495-8.

13. Joint Commission on Accreditation of Healthcare Organizations USA. Preventing maternal death. Sentinel Event Alert 2010;44:1-4.

14. Burtelow M, Riley E, Druzin M, Fontaine M, Viele M, Goodnough LT. How we treat: management of life-threatening primary postpartum hemorrhage with a standardized massive transfusion protocol. Transfusion 2007;47:1564-72.

15. Upadhyay K, Scholefield H. Risk management and medicolegal issues related to postpartum hemorrhage. Best Pract Res Clin Obstet Gynaecol 2008;22:1149-69.

16. Dildy GA III, Paine AR, George NC, Velasco C. Estimating blood loss: can teaching significantly improve visual estimation? Obstet Gynecol 2004;104:601-6.

17. Bose P, Regan F, Paterson-Brown S. Improving the accuracy of estimated blood loss at obstetric hemorrhage using clinical reconstructions. BJOG 2006;113:919-24.

18. Toledo P, McCarthy RJ, Burke CA, Goetz K, Wong CA, Grobman WA. The effect of live and web-based education on the accuracy of blood-loss estimation in simulated obstetric scenarios. Am J Obstet Gynecol 2010;202:400.e1-5.

19. Crofts JF, Ellis D, Draycott TJ, Winter C, Hunt LP, Akande VA. Change in knowledge of midwives and obstetricians following obstetric emergency training: a randomized controlled trial of local hospital, simulation center and teamwork training. BJOG 2007;114:1534-41.

20. Al-Zirqi I, Vangen S, Forsen L, Stray-Pedersen B. Prevalence and risk factors of severe obstetric hemorrhage. BJOG 2008;115:1265-72.

21. New York Department of Health. Managing maternal hemorrhage, 2004. Available at: http://www.health.state.ny.us/professionals/protocols_and_guidelines/maternal_hemorrhage/. Accessed Feb. 15, 2011.

22. Belfort MA. Placenta accreta. Am J Obstet Gynecol 2010;203:430-9.

23. Patel A, Goudar SS, Geller SE, et al. Drape estimation vs visual assessment for estimating postpartum hemorrhage. Int J Gynaecol Obstet 2006;93:220-4.

24. Tourne G, Collet F, Lasnier P, Seffert P. Usefulness of a collecting bag for the diagnosis of post-partum hemorrhage [in French]. J Gynecol Obstet Biol Reprod (Paris) 2004;33:229-34.

25. Hirshberg A, Dugas M, Banez EI, Scott BG, Wall MJ Jr, Mattox KL. Minimizing dilutional coagulopathy in exsanguinating hemorrhage: a computer simulation. J Trauma 2003;54:454-63.

26. Gonzalez EA, Moore FA, Holcomb JB, et al. Fresh frozen plasma should be given earlier to patients requiring massive transfusion. J Trauma 2007;62:112-9.

27. Borgman MA, Spinella PC, Perkins JG, et al. The ratio of blood products transfused affects mortality in patients receiving massive transfusions at a combat support hospital. J Trauma 2007;63:805-13.

28. Stinger HK, Spinella PC, Perkins JG, et al. The ratio of fibrinogen to red cells transfused affects survival in casualties receiving massive transfusions at an army combat support hospital. J Trauma 2008;64:S79-85.
29. London A, Lagrew D, Shields L, Melsop K, Bingham B, Main E. Improving health care response to obstetrical hemorrhage, 2010. Available at: http://www.cmqcc.org/ob_hemorrhage. Accessed Feb. 15, 2011.
30. Cameron CA, Roberts CL, Bell J, Fischer W. Getting an evidence-based post-partum hemorrhage policy into practice. Aust N Z J Obstet Gynaecol 2007;47:169-75.
31. Deneux-Tharaux C, Dupont C, Colin C, et al. Multifaceted intervention to decrease the rate of severe postpartum hemorrhage: the PITHAGORE6 cluster-randomized controlled trial. BJOG 2010;117:1278-87.
32. Skupski DW, Lowenwirt IP, Weinbaum FI, Brodsky D, Danek M, Eglinton GS. Improving hospital systems for the care of women with major obstetric hemorrhage. Obstet Gynecol 2006;107:977-83.