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BUILDING HOSPITAL SYSTEMS FOR MANAGING MAJOR OBSTETRIC HEMORRHAGE

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INTRODUCTION

Maternal death from major obstetric hemorrhage is a leading killer of women world-wide, as most of the chapters in this book amply demonstrate. Attention to this topic is not glamorous, unfortunately, but few topics can be more important in improving the health of reproductive-aged women throughout the world. This chapter demonstrates a proven, in-hospital approach to decreasing morbidity and mortality of women with major obstetric hemorrhage[1]. The program hinges on building, developing and improving existing hospital systems that are necessary for the care of such women.

BACKGROUND

In the United States, the need for Cesarean hysterectomy as well as the incidence of major obstetric hemorrhage have both increased in recent years[2–4], most likely due to the known increase in Cesarean and repeat Cesarean delivery with their respective increases in placenta previa and accreta, especially in patients undergoing repeat Cesarean delivery[2–4]. In the setting of intractable obstetric hemorrhage, emergency peripartum hysterectomy is used as a life-saving procedure. According to one recent article, the incidence of emergency peripartum hysterectomy is approximately 2.5/1000 deliveries[3] and hemorrhage associated with uterine atony is the most frequent indication, followed by placenta accreta[5]. Apart from whether or not hysterectomy need be performed, maternal death is a known complication of major obstetric hemorrhage[6].

TACKLING THE PROBLEM OF MAJOR OBSTETRIC HEMORRHAGE

Recently developed programs to improve outcomes for women with major obstetric hemorrhage have focused on at least two important factors: first, the initial response to the hemorrhage, and, second, the prevention of hemorrhage in those patients who can be identified as being at high risk for it. This latter effort is in recognition of the fact that two of the three most common causes of hemorrhage cannot be identified in advance. These are uterine atony and/or placenta previa and placenta accreta[4]. In contrast, only placenta previa is reliably able to be diagnosed in advance.

Any program aimed at improving outcomes from major obstetric hemorrhage must also consider the interface of individuals and departments that may not traditionally be thought of as important in the process of caring for women with obstetric hemorrhage. The remainder of this chapter describes the details of these hospital systems and, in particular, how they have recently been revised with good effect in a major New York teaching hospital.

IMPORTANCE OF COMMUNICATION AND EDUCATION

Two extremely important and overarching processes must be initially addressed in order for any program aimed at improving outcomes to be successful: communication and education. It cannot be over-emphasized that clear channels of communication must be developed between all the people and departments that are involved in caring for women with major obstetric hemorrhage. This includes the immediate and

coordinated communications that are inevitably necessary for any rapid response team to work at maximum capacity. This communication must be far more comprehensive than just the members of the obstetric department and may need to include members of the emergency department, anesthesiology, the labor and delivery suite, nursing administration, the operating rooms, and the blood bank, to name just a few.

Basic education is equally important, and it is imprudent to believe that attending or house staff will know (a priori) all the component parts of the program based on their past experience and training. All care providers who evaluate these patients and institute therapy must possess the requisite knowledge of the pathophysiology of hemorrhagic shock in order to identify the presence and assess the severity of this problem, and to begin the process of initial treatment. It cannot be over-emphasized to all levels of staff that the diagnosis is not always as easy as training manuals might suggest. The involvement of departmental leaders who are experienced with the management of obstetric hemorrhage and available on a 24/7/365 basis is key. When they become primary stakeholders in the educational process, training for less experienced care providers should be developed and be repeated on a regular basis. Training such as this should be thought of as a continuous process – something that has to be repeated to every new rotation of house staff and attending consultants.

EVENTS AT NYHQ

The New York Hospital Medical Center of Queens (NYHQ) is an acute care 480-bed hospital in Flushing, New York, affiliated with the Weill Medical College of Cornell University, and the New York Presbyterian Hospital. The hospital serves an urban community of great ethnic diversity who are insured by both commercial and governmental payers; the hospital is designated for the highest level (Level III) of Neonatal Intensive and Maternal Care, and also has the highest designation for a Trauma Center (Level I). Separate critical care units are dedicated to Surgical, Medical and Cardiac services.

Two maternal deaths due to major obstetric hemorrhage occurred in recent years, one in the year 2000 and one in the year 2001. This circumstance prompted the creation of a patient safety team that worked to improve the hospital systems at NYHQ for caring for women at risk for, or suffering from, major obstetric hemorrhage. This patient safety team chose as its mission and was successful in the creation of an improved management scheme (clinical pathway) for the identification and management of major obstetric hemorrhage, with the express intent of reducing maternal deaths due to this cause.

Patient safety teams

Beginning in 2001, a multidisciplinary patient safety team was established that included individuals from the medical divisions of Obstetric Anesthesiology, Maternal Fetal Medicine, Neonatology and the Blood Bank, as well as the hospital departments of Nursing, Communication and Administration. Over the course of 6–12 months, meeting usually every week for 1–2 h, the newly created patient safety team evaluated the totality of the medical center's care of the two women who died from major obstetric hemorrhage, considered both the proximate and systems-related causes of these unfortunate outcomes, discussed possible recommended changes in the management, and decided on how best to change the systems at NYHQ that were then present for the care of women who might find themselves in similar circumstances.

Objective of our study

In order to assess the impact of the proposed changes in hospital systems on the outcomes of our patients, we began to carefully record a variety of pertinent outcomes prospectively from that point forward, and looked back retrospectively to record the same outcomes for the 2 years in which the deaths had occurred. The committee was of the opinion that the accurate recording of outcomes was essential to demonstrate any effect of changes in management over time. Specifically, we hypothesized that the changes we implemented in our hospital systems would lead to improved outcomes for women with major obstetric hemorrhage.

Methods

A multifaceted approach included the following:

(1) We formed an obstetric rapid response team (Team Blue), modeled it after the cardiac arrest team, and included quarterly mock drills on all shifts for various emergency clinical scenarios.

(2) We developed clinical pathways – guidelines and protocols – specifically designed to provide for early diagnosis of patients at risk for major obstetric hemorrhage and for streamlined care in emergency situations.

(3) In response to a marked increase in the volume of gynecologic emergency cases and births at NYHQ, we separated the in-house obstetric and gynecologic responsibilities to allow the in-house obstetrician to focus on obstetric emergencies without fear of neglecting gynecological emergencies.

(4) We revised the duties of the 24-h in-house staff (consultant) obstetrician to include continuous and frequent monitoring of all patients on the Labor and Delivery unit. This monitoring included those patients who had private obstetricians who might not be present on a continuous basis.

(5) We empowered all obstetric care providers (including physician assistants, nurses, resident physicians and the in-house attending physician) to immediately involve senior members of the Department whenever there was disagreement with or concern about the management scheme (particularly when there was a possible delay in recognition of the severity of hemorrhage). A senior member of the Department was then required to discuss the issue immediately with the attending physician to avoid delay.

(6) Through weekly didactic sessions, we educated all of our staff to recognize the severity of hemorrhage described in the Advanced Trauma Life Support Manual of the American College of Surgeons[7], and disseminated information regarding the new protocols for patient care. The attending, nursing and ancillary staffs were all informed regarding the intent of the changes (i.e. to improve patient safety) and the importance of early diagnosis of major hemorrhage.

(7) We established the role of the existing Trauma Team (with the full agreement of the Director of the Trauma Division) to specifically respond and assist in cases of severe obstetric hemorrhage, because the Trauma Team was the most experienced in resuscitation of patients with hemorrhagic shock within our institution. The Trauma Team includes surgical house officers working under the direction of the surgical trauma attending physician. These team members are expert in the placement of large-bore intravenous lines (by venous cut-down if necessary), are knowledgeable about the physiology of volume resuscitation, assist in obtaining adequate amounts of blood products for massive blood replacement, and also are most experienced in inserting intraluminal lines directly into the major vessels for monitoring and obtaining requisite samples.

The creation of new protocols and guidelines

The following protocols and guidelines were created to enhance the reception and perpetuation of the new activities.

- We prepared for major hemorrhage in patients with known placenta previa (Figure 1). This preparation included antenatal consultation with Maternal Fetal Medicine, Obstetric Anesthesiology and senior gynecologic surgeons; liberal use of ultrasound to identify placenta accreta in patients with prior uterine surgery and/or placenta previa. When such patients were identified, they received twice-weekly type and screen to allow for more rapid availability of blood products if major hemorrhage occurred. Amniocentesis was performed for fetal lung maturity at 36 weeks of gestation followed by planned Cesarean delivery if the fetal lungs were shown to be mature.
- We prepared for major hemorrhage in patients in whom we suspected placenta

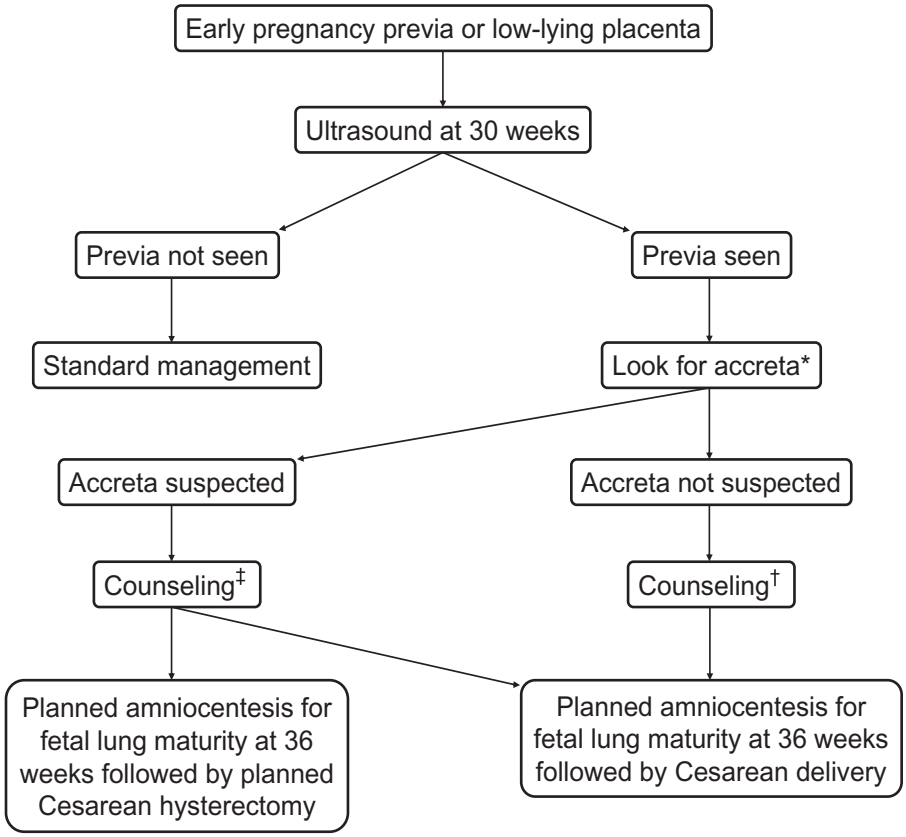

Figure 1 Proposed management scheme for patients at risk for major obstetric hemorrhage. CD, Cesarean delivery. *Suspicion for accreta is markedly increased with prior CD and anterior placenta; †includes bed rest, pelvic rest, preparation for CD, serial CBC, consider erythropoeitin, iron and vitamin supplements and serial autologous blood donation; ‡includes the counseling above and a recommendation for Cesarean hysterectomy. Low parity may decrease the strength of the recommendation if future child-bearing is desired

accreta (Figure 1). This included autologous blood donation as often as every week for a period of 4–5 weeks before the planned Cesarean delivery; erythropoietin, iron and vitamin therapy in an effort to boost red blood cell production; consultation with interventional radiology in which we would consider placement of ports preoperatively, so that embolization of major pelvic blood vessels could occur rapidly in the event of substantial hemorrhage during the operation; judicious placement of additional intravenous lines and a 7.5 French internal jugular cordis for invasive monitoring and volume replacement; intraoperative monitoring with an arterial line and central venous pressure; and transfer to the surgical intensive care unit as needed. In addition, we used the Cell Saver, but only after delivery of the fetus and after copious peritoneal irrigation had been performed[4]. Weekly autologous blood donation not only was used to prevent introduction of blood-borne infection with transfusion but also contributed to resolving any potential shortage of blood in our area.

- We obtained consultation with the Trauma Team as necessary.
- For patients with suspected placenta accreta, we discussed the likely decreased maternal mortality of planned Cesarean hysterectomy[8]. Planned Cesarean hysterectomy was then performed for those who agreed.

- For patients with suspected placenta accreta, Cesarean delivery and Cesarean hysterectomy were scheduled in the main operating room under the direction of senior gynecologic surgeons (Figure 1), because staff and facilities of the main operating room are better equipped to perform hysterectomy than is the case with the Labor and Delivery suite. This procedural change also avoided the problem of consuming staff and resources on Labor and Delivery that were considered necessary for the care of other patients.

Table 1 shows the hospital systems involved, along with an assessment of the impact on improving outcomes in women with major obstetric hemorrhage and the relative amount of work involved in the change.

In addition to the changes in systems detailed above, data on obstetric volume, mode of delivery, occurrence of major obstetric hemorrhage and outcomes important in identifying improvements were collected from 2000 to 2005. Cases were identified prospectively for the entire patient cohort (2000–2005). Demographic and outcome data on each patient were recorded retrospectively during the time period of January 2000 to May 2001 and prospectively beginning in June 2001.

The data collection program also involves monitoring by senior Departmental leaders who receive reports on a daily basis from care providers regarding all cases of major obstetric hemorrhage. These cases were highlighted and included in the database as they occurred. Outcomes analyzed included maternal deaths, lowest documented maternal pH, lowest documented maternal temperature, and the occurrence of coagulopathy.

Our definition of major obstetric hemorrhage included one or more of the following: estimated blood loss = 1500 ml, need for blood transfusion, need for uterine packing, performance of uterine artery ligation, and performance of Cesarean hysterectomy. Admittedly, this definition is different from that of postpartum hemorrhage that has been detailed in other chapters of this volume. Accordingly, the rate of major obstetric hemorrhage by our definition was expected to be lower than the known incidence of postpartum hemorrhage. Data were compared between the 2 years before

Table 1 Impact of hospital system changes on the outcomes of women with major obstetric hemorrhage

Specific change	*Impact*	*Amount of work*
Administrative		
Patient safety team	critical	extensive
Trauma Team involvement	minor	moderate
Departmental		
Obstetric rapid response team	critical	extensive
Development of clinical pathways or guidelines	major	moderate
Dissemination of clinical pathways or guidelines	major	moderate
Separation of in-house obstetrician and gynecologist	minor	moderate
Culture change to proactive attending physician	major	moderate
Care provider empowerment	major	moderate
Didactic teaching about physiology and treatment of hemorrhagic shock	major	moderate
Clinical pathways or guidelines		
Antenatal management of known placenta previa	major	moderate
Preparation for hemorrhage in suspected placenta accreta	minor	moderate
Counseling about planned Cesarean hysterectomy	minor	minimal
Scheduled Cesarean delivery for previa and accreta in the main operating room	minor	minimal
Nursing		
Culture change to team participation	major	extensive
Empowerment of nurses	major	moderate

Table 2 Major obstetric hemorrhage in the period 2000–2005

Year	*Births*	*Total Cesarean births*⋆	*Repeat Cesarean births*†	*Cases of major obstetric hemorrhage*‡	*Cesarean hysterectomy*§	*Mortality*
2000	2705	516	217	3	1	1
2001	3106	801	287	8	5	1
2002	3323	903	332	8	5	0
2003	3395	932	326	14	4	0
2004	3648	1053	374	18	5	0
2005 (8 months)	2546	759	275	12	4	0
Total	18 723	4964	1811	63	24	2

⋆2000–2001 compared to 2002–2005, $p < 0.0001$; †2000–2001 compared to 2002–2005, $p = 0.002$; ‡2000–2001 compared to 2002–2005, $p = 0.02$; §rate of Cesarean hysterectomy as a function of the total number of major obstetric hemorrhage cases 2000–2001 compared to 2002–2005, $p = 0.37$

and the 3 years after the systemic changes were implemented, 2000–2001 vs. 2002–2005.

Results

During each successive year of the study, the following important changes occurred simultaneously: increasing obstetric volume, increasing rate of Cesarean delivery, an increasing rate of repeat Cesarean delivery, and an increasing number of cases of major obstetric hemorrhage (Table 2). The increases in Cesarean delivery, repeat Cesarean delivery, and cases of major obstetric hemorrhage all were significant between the time periods of 2000–2001 vs. 2002–2005, but no difference was shown in the rate of Cesarean hysterectomy (Table 2).

Clinical characteristics, measures of severity of hemorrhage and outcomes are shown in Table 3. The patient groups from the two time periods (2000–2001 vs. 2002–2005) were similar in demographics as measured by age, parity and incidence of prior Cesarean delivery. The severities of obstetric hemorrhage also appeared to be similar between the time periods. The severity measures were APACHE II scores[9], occurrence of placenta accreta and amount of estimated blood loss (Table 3).

The major result of the combined effort was that maternal deaths were significantly reduced in the time period following the systemic changes ($p = 0.036$). This was supported by the additional findings of significant differences in lowest pH ($p = 0.004$) and lowest temperature ($p < 0.0001$). There also was a trend toward less coagulopathy ($p = 0.09$). These diverse findings were very important, because it is known that a triad of physiologic derangements occurs in hemorrhagic shock that can lead to death. This triad comprises acidemia, hypothermia and coagulopathy. Its presence helps to confirm that our major finding of reduced maternal death is not a statistical chance event, and also argues that our response to the event of a major obstetric hemorrhage became better as time passed and as care providers became more experienced and knowledgeable.

The two time periods were also analyzed according to other characteristics, such as need for Cesarean hysterectomy, volume of transfusion, operative time, need for intubation for greater than 24 h, and number of hours intubated (Table 3). No significant differences were present in these measures in the periods 2000–2001 vs. 2002–2005. The incidence of peripartum hysterectomy was 1.3/1000 (24/18 723) during the entire study period (2000–2005). Placenta accreta with prior Cesarean delivery accounted for 14/24 (58.3%) cases of Cesarean hysterectomy, and we suspected accreta in seven cases and confirmed it in four cases at delivery. The operative characteristics, morbidity and mortality of patients undergoing peripartum hysterectomy are shown in Table 4. The numbers here are different from Table 3, because Table 3 shows all patients

Table 3 Major obstetric hemorrhage: comparison of demographics, measures of severity and outcomes

	2000–2001 (*n* = 12)	*2002–2005* (*n* = 49)	*p Value*
Demographics			
Age, mean (SD)	36.5 (6.0)	34.2 (5.9)	0.23
Parity, median (range)	1 (0–3)	1 (0–5)	0.70
Prior Cesarean delivery, *n* (%)	6 (50.0)	32 (65.3)	0.33
Severity measures			
Occurrence of placenta accreta, *n* (%)	4 (33.3)	11 (22.4)	0.46
APACHE score, median (range)	11.5 (7–31)	10 (6–18)	0.07
Estimated blood loss, mean (SD)	2725 (1289)	2429 (1214)	0.46
Outcomes			
Maternal death, *n* (%)	2 (16.7)	0 (0.0)	0.036*
Lowest pH, median (range)	7.23 (6.8–7.39)	7.34 (7.08–7.44)	0.004*
Lowest temperature (°C), median (range)	35.2 (30.2–35.8)	36.1 (35.2–37.8)	< 0.0001*
Coagulopathy, *n* (%)	7 (58.3)	15 (30.6)	0.09
Cesarean hysterectomy, *n* (%)	6 (50.0)	18 (36.7)	0.51
Volume of transfusion, mean (SD)	1313 (1029)	1194 (1547)	0.80
Operative time, mean (SD)	185 (91)	184 (79)	0.99
Intubation > 24 h, *n* (%)	7 (58.3)	16 (32.7)	0.18

*Significant difference

during the entire study period and the data in Table 4 is confined to those patients who underwent Cesarean hysterectomy. Interestingly, a significant difference was also present in the lowest pH in patients undergoing Cesarean hysterectomy between the time periods of 2000–2001 vs. 2002–2005. We think this underscores that our response to women with hemorrhagic shock from blood loss improved over the course of time.

Deciphering the data

The response to major obstetric hemorrhage must be multifaceted and rapid in order to be successful. A quality assurance committee would be the traditional departmental or institutional response to a poor outcome such as a maternal death from hemorrhage, and, after this peer review, specific physician education would occur regarding the components of early identification and 'best' treatment, as determined by departmental leaders. However, this traditional response ignores the lessons learned from the Institute of Medicine report regarding errors that lead to morbidity and mortality during hospital stays[10]. When clinical judgment fails and hemorrhagic shock is not recognized or when a patient presents in an advanced state of hemorrhagic shock, a need to improve hospital systems to provide a safety net for patients is as important as is the education of a specific physician or group of physicians after an adverse outcome.

Our findings indicate that there were significant improvements in outcomes after we introduced systemic changes at our institution, including improvements in maternal deaths, lowest pH and lowest temperature. There were no difference in measures of severity of obstetric hemorrhage and significant increases in the number of cases of major obstetric hemorrhage between the study time periods, leading us to the conclusion that this improvement in outcomes is a true finding. When comparing the time periods before and after the systemic changes, the significant differences in lowest temperature and in lowest pH (Table 3) suggest that the team's response to massive hemorrhage improved after system-wide interventions. The reduction in maternal mortality, however, cannot be considered a robust observation, because this observation is hospital-based and may not be replicated in a population-based sample.

Table 4 Peripartum hysterectomy in the period 2000–2005. Incidence: 24/18 723 (1.3/1000). All data are number of cases unless otherwise designated

	2000–2001[†]	*2002–2005*[‡]	*Total*[§]
Etiology			
Placenta accreta	4	10	14
Placenta accreta with prior CD	4	10	14
Uterine atony	2	6	8
Morbidity			
Cystotomy	1	1	2
Pulmonary embolus	1	0	1
Coagulopathy	5	8	13
Acute tubular necrosis	0	0	0
ARDS	0	0	0
Myocardial infarction	0	0	0
Pneumonia	0	0	0
Mortality			
Placenta percreta	1	0	1
Other characteristics			
Operative time (min), mean (SD)	259 (52.3)	250 (66.6)	252 (62.4)
EBL (ml), median (range)	3500 (2500–5200)	3000 (1000–7000)	3250 (1000–7000)
Transfusion total volume (ml), mean (SD)	2125 (847.8)	2292 (2076.4)	2250 (1829.9)
FFP/platelets given (*n*)	5	10	15
Lowest pH, mean (SD)	7.15* (0.17)	7.27* (0.07)	7.24 (0.12)
Intubated	5	12	17
Intubated > 24 h	3	3	6
Days to discharge, median (range)	6 (4–7)	4 (3–11)	5 (3–11)
Anesthetic management			
Regional anesthesia only	1	3	4
Conversion to general	2	12	14
General anesthesia only	3	3	6

[†]2000–2001 hysterectomy $n = 6$, total births $n = 5811$; [‡]2002–2005 hysterectomy $n = 18$, total births $n = 12\,912$; [§]2000–2005 (total) hysterectomy $n = 24$, total births n = 18 723; *significant difference $p = 0.02$

CD, Cesarean delivery; ARDS, adult respiratory distress syndrome; SD, standard deviation; EBL, estimated blood loss; FFP, fresh frozen plasma

This caveat in no way diminishes the value of our findings in terms of their broad applicability in other hospitals throughout this and other countries.

The process of implementing the systemic changes required considerable effort by many individuals and was very time-intensive. The patient safety team met numerous times and deliberated on the specifics of our response. These efforts included repeated education of care providers on the diagnosis and management of hypovolemic shock. It is of considerable interest that the entire staff accepted these additional time expenditures as part of their ongoing self-education and were proud of the outcome and the results (Table 1).

This study design does not allow a determination of which of several interventions may have accounted for improvements in outcome. We strongly believe that the data presented in this chapter support the conclusion that a well-reasoned, carefully constructed and multifaceted program focusing on patient safety can improve outcomes, although we cannot

attribute any specific improvement to any specific change that we instituted. We also strongly believe that our experience demonstrates that focusing on the problem of obstetric hemorrhage by the medical and administrative departments in a given hospital can and does lead to improved outcomes. The effort involved is substantial, but rewarding.

FINAL COMMENTS

The risk of placenta previa with or without accreta in patients with multiple Cesarean deliveries is difficult to quantitate[11]. However, recently published prospective data[12,13] corroborate previously published retrospective data on the substantial risk of accreta associated with previa and prior Cesarean[14]. Placenta previa is a detectable condition, allowing for a preventive clinical pathway such as that developed in Figure 1 to be implemented. We believe that the preparation that takes place after the early identification of patients at risk is an important component in the ability to improve outcomes for our program.

When confronted with adverse outcomes, principles of quality improvement require that 'systems' thinking take place. It is tempting to attempt to correct the proximate cause (e.g. an individual physician's lack of attention to detail or suboptimal clinical judgment on an individual case) without addressing the 'systems'. We believe these data support the clear need for a systemic response and hope they are useful to others faced with the task of improving safety in obstetric suites. The specific series of changes in systems at our institution was uniquely adapted to the circumstances we encountered. It is possible that these changes may not be as important nor as easily achievable in other areas of the world. However, in any institution's response to major obstetric hemorrhage, it is important to keep in mind the numerous and potentially changing nature of obstacles to system changes and the need to put together a multidisciplinary response to overcome these obstacles. Though this is a challenging task, the result of improvements in outcomes for women with obstetric hemorrhage remains rewarding and, most importantly, achievable.

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