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Hidden Danger! Insidious Postpartum Bleeding After Emergency Cesarean Delivery.

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The Case

A 32-year-old pregnant woman presented to Labor and Delivery with prelabor rupture of membranes at 37 weeks' gestation. She had significant obstetric history with 5 prior vaginal deliveries, all at term, with no attendant complications. The fetal heart rate (FHR) at presentation was category 2, described as moderate variability with normal baseline; accelerations were present with sporadic variable decelerations. On vaginal examination, her cervix was noted at 7 cm, right occiput transverse, -1 station, with adequate contractions coming every 3 minutes. Regional anesthesia was requested.

After dosing of regional anesthesia, the patient was placed in supine position with a leftward tilt. The FHR and uterine monitors were adjusted when suddenly FHR dropped to 60 beats per minute below baseline. Oxygen via face mask and position change were initiated, but the FHR remained depressed for 120 seconds without signs of returning to baseline. Upon vaginal examination, the obstetric provider diagnosed umbilical cord prolapse and called for an emergency cesarean delivery for fetal bradycardia. The infant was born 10 minutes after the cesarean was called with Apgar scores of 4 (1 minute) and 9 (5 minutes). Umbilical cord gases showed mixed acidosis with an arterial pH of 7.0 and base excess of -12. Uterine atony was noted after delivery of the placenta, which quickly responded to oxytocin bolus and uterine massage with a quantitated blood loss (QBL) of 1200 ml. The patient was hemodynamically stable when transferred to the post-anesthesia care unit (PACU) with intravenous fluid running at 125 ml/hour, and vital signs to be checked every 15 minutes, according to protocol.

Through the first 90 minutes in the PACU, the uterine fundus remained moderately firm. Vital signs showed systolic blood pressure around 90 mm Hg, mean arterial pressure (MAP) 60-70, pulse 110-120/min, respiratory rate 24-28/min. The patient was deemed stable. All monitor alarm functions were silenced to help the patient rest until a bed became available on the maternity floor. After 180 minutes in the PACU, the patient's nurse discovered her unresponsive and the bedsheets were blood-soaked. The obstetrician

and anesthesiologist were summoned and responded quickly. At that time, the patient's vital signs showed a blood pressure of 88/40, mean arterial pressure of 57, pulse 142/min, respiratory rate 26/min, and 98% oxygen saturation. The intravenous fluid was opened up as a bolus. The uterus was boggy on examination. Uterotonic medications were ordered and administered. Quantitated blood loss was estimated at 1500 ml. A massive transfusion protocol was ordered. The patient remained hypotensive and tachycardic with continued vaginal bleeding, so the decision was made to return to the operating room for laparotomy and possible hysterectomy. Upon abdominal entry, the uterus was noted to be atonic despite uterotonic therapy. There was no other source of bleeding. Given the patient remained hemodynamically unstable, she underwent an emergency hysterectomy. As she continued to bleed after surgery, she had angiography and embolization of a small bleeding artery in the pelvis. She was transferred to the intensive care unit (ICU) and required intubation and mechanical ventilation for two days. She made a complete recovery without any sequelae.

The Commentary

By Gary S. Leiserowitz, MD, MS and Herman Hedriana, MD

Hundreds of women die in childbirth annually in the United States; 60% of these deaths are considered preventable.[1] The U.S. has an increasing rate of maternal mortality of 17 maternal deaths per 100,000 and is ranked 60th in the world.[2] The number of women with severe maternal morbidity greatly exceeds the number of deaths, increasing > 75% from the late 1990's through 2009.[2] Based on a review of 14 Maternal Mortality Review Committees (state and local) from 2008 - 2017, the causes of death in decreasing frequency were: cardiovascular conditions, hemorrhage, infection, embolism, cardiomyopathy, mental health conditions, and pre-eclampsia/eclampsia (cumulatively responsible for about 75% of deaths).[3] In this review, the CDC estimated that 65.8% were preventable. The leading causes also varied by race. Cardiomyopathy and cardiovascular conditions were leading causes of death in non-Hispanic Black women, whereas mental health conditions were the leading cause in non-Hispanic White women. Hemorrhage was a cause of death in about 13% of all women. Mental health causes of maternal death appear related to drug overdose and suicide.[4]

The causes of maternal death have changed over time. The triad of infection, hemorrhage, and hypertensive disorders previously accounted for more than 90% of deaths, but now account for about one-third.[4] With medical advances and use of assisted reproductive technology, many women are now able to become pregnant who would have been unable to so in prior decades. Also, many women are delaying childbearing until later in their reproductive life, which can increase the risk for co-morbid medical conditions, including cardiovascular, cerebrovascular, and other conditions. Increasing maternal age is strongly correlated with increased risk of maternal death; 27% of maternal deaths occur in women over age 35.[5] This age-related mortality risk is especially pronounced for non-Hispanic Black women, who have 4 times higher mortality than white women of similar age. Low socioeconomic status, Medicaid insurance status, and obesity also increase the risk for severe obstetric morbidity.[5,6]

Creanga et al. used the Pregnancy Mortality Surveillance System with data from 2006 through 2010[5] and found that hemorrhage was the cause of death in 11.4% of cases, with the following specific etiologies: ruptured ectopic (3.0%), uterine rupture (1.1%), placental abruption (1.1%), placenta accreta (1.4%),

uterine atony (1.8%), and other (2.8%). Other etiologies that manifest in abnormal vital signs and/or mental status changes included embolism (14.9%), hypertensive crisis (including pre-eclampsia/eclampsia, 9.4%), infection (13.6%), cardiomyopathy (11.8%), cerebrovascular accident (6.2%), and cardiovascular conditions (14.6%).

Given that more than 60% of maternal deaths are preventable the challenge for obstetric providers is to develop early detection systems that might trigger timely intervention. In this case, there was a potentially preventable etiology of severe maternal morbidity that might have been mitigated by earlier intervention. The physiology of pregnancy is substantially altered compared to the non-pregnant state to support the developing fetus and to provide a buffer in case complications arise. These alterations include increased blood volume, increased cardiac output, decreased vascular resistance (with lower blood pressure), increased pulse, increased respirations, increased minute ventilation, decreased functional residual capacity, increased glucose metabolism, and others.[7] Altered pregnancy physiology can make it challenging to recognize any early clinical deterioration. Nevertheless, acknowledging these adjustments in maternal physiology allows for the recognition of abnormal triggers, which would inform an early warning system tailored to pregnant women.

Early Warning Systems

Multiple institutions and organizations have developed protocols and mechanisms to better identify pregnant patients who are at high risk of clinical decompensation in the peri-partum period. These protocols are evidence-based and customizable, aid in timely diagnosis and treatment, and can facilitate improvements in the quality of maternal care.[2] They commonly use triggers associated with impending serious conditions. An example is a set of physiological changes along with alterations in cognition, known as maternal early warning criteria (MEWC), that was developed through the National Partnership for Maternal Safety.[8] These criteria include systolic BP (mm Hg) <90 or >160, heart rate <50 or >120, oxygen saturation on room air <95%, and status changes such as agitation, confusion, dyspnea, and/or non-remitting headache. These criteria are somewhat analogous to what has been developed for medical admissions but modified based on maternal physiology.[9] When triggered, this early warning system would lead to a targeted evaluation to determine the etiology, and if confirmed, should result in appropriate intervention. Since these triggers are based on objective physiological changes and/or cognition, they should be less influenced by the patient's race/ethnicity, helping to minimize the risks of implicit bias.

Several early maternal warning systems are available: modified early obstetric warning score (MOEWS), maternal early recognition criteria (MERC), modified early warning system (MEWS) and maternal early warning trigger (MEWT).[10] All of these algorithms use pre-defined physiologic parameters as triggers, can be assessed at bedside, and are designed to lead to intervention. Some use a single abnormality to trigger a response (MERC),[8] while others use a combined score (MEWS and MOEWS).[11,12] MERC was proposed by the National Partnership for Maternal Safety as a system that favors simplicity and specificity over complexity and sensitivity.[8] The authors note that in reviews of maternal mortality, a disproportionate share of patients showed clearly abnormal vital signs that should have triggered intervention. The MERC system's simplicity makes it an attractive option for most obstetric units that have a normal spectrum of maternal conditions (as opposed to high acuity units characterized by complex maternal conditions).

In contrast with other early maternal warning systems, MEWT requires that the physiologic abnormality(ies) be persistent over time (>20 minutes), to avoid a premature trigger of intervention.[13] It was designed to address the four most common sources of maternal morbidity: sepsis, cardiopulmonary dysfunction, pre-eclampsia/hypertension, and hemorrhage. The MEWT algorithm includes both the defined triggers as well as the recommended interventions in a flow diagram that is readily available to obstetric providers and nurses. It was piloted in 6 hospitals in a regional system with 29 maternity facilities in California. Comparing the before and after implementation phases at the 6 pilot hospitals vs. the 23 others, implementation of the MEWT tool was followed by significant reductions in severe maternal morbidity at the pilot hospitals, with no concurrent trends at the non-pilot hospitals. The numbers of ICU admissions were unchanged. Hedriana and colleagues also did a retrospective case-control study of obstetric patients admitted to an ICU and analyzed the test performance of the MEWT system to identify maternal morbidity.[14] They found that sustained MEWTs (2 or more, lasting 30 minutes or longer) had strong positive predictive value (72% detection rate) and a false-positive rate of 4%. For 62% of these patients, detailed chart review suggested that earlier intervention (e.g., bedside involvement of the provider or a rapid response team) might have changed the degree of maternal morbidity.

There are no head-to-head comparisons, but Blumenthal et al. did a retrospective analysis of severe maternal morbidity cases at an academic institution, applied the four maternal warning systems, and assessed their accuracy to distinguish between cases (79) and controls (123).[10] The test performances of the four systems varied significantly; MEOWS and MERC were more sensitive (67.1% and 67.1%, respectively, versus 19% for MEWS and 40.5% for MEWT) but MEWS and MEWT were more specific (93.5% and 88.6%, respectively, versus 51.2% for MEOWS and 60.2% for MERC). Because the MEWT system requires a sustained positive trigger, it was less affected by transitory alarms. For example, single parameter alerts such as a diastolic blood pressure >90 mm Hg were common in the MEOWS system, accounting for 88% of alerts. None of the four tools performed with 90% sensitivity and 95% specificity. The authors noted that in an obstetric unit with high volume and acuity, the MEWT system performed the best with a positive predictive value of 70%, due to its higher specificity with fewer false positive alerts. MEWT was felt to provide clinically relevant information in 89% of alerts, compared to less than 50% for MEOWS and MERC.

Using this case as an example, the MEWT system would have been triggered, based on 2 maternal triggers (pulse >110 and respiratory rate >24) that were sustained for more than 30 minutes. (By comparison, MERC might not have triggered, because of its higher pulse threshold of 120 and respiratory rate threshold of 30.) The patient did not appear clinically ill, and so alarms were silenced without further evaluation. These triggers preceded the patient's clinical deterioration, when she became non-responsive in the setting of hemorrhage and profound hypotension. Fortunately, the actual source of the patient's condition was recognized in time, but heroic interventions were required. Although death was averted, it seems quite evident that earlier investigation and intervention might have led to less morbidity.

Systems Approach to Patient Safety

Two other issues should be highlighted. As noted at the beginning of the commentary, obstetric hemorrhage remains a major cause of maternal death, which is readily preventable. A previous WebM&M commentary notes that obstetric hemorrhage remains an under-recognized danger since it is often

concealed from view (especially when intra-abdominal). Because of the increased blood volume and decreased vascular resistance seen late in pregnancy, blood loss can be profound prior to recognition, at which point the patient is severely compromised. The obstetric hemorrhage bundle described by the California Maternity Quality Care Collaborative (CMQCC) is an excellent example of standardized protocols that have proven to be effective interventions.[15,16] A key element in the CMQCC response plan is a formalized checklist that is well organized, includes a list of likely etiologies, expedited evaluation, and action plans stratified by stages of severity – ranging from moderate to life-threatening. The intervention plans start on the left of the chart with “Mobilize”, then “Act” and on the right with “Think”. The strength of this checklist is that it clearly spells out a plan that avoids missing critical elements that are easy to overlook in an emergency. This checklist readily meets the standards described in the American College of Obstetricians and Gynecologists (ACOG) Committee Opinion on Clinical Guidelines and Standardization of Practice to Improve Outcomes by avoiding unnecessary variation in approach.[15]

The last issue is that frequent alerts can lead to alarm fatigue. Medical devices are a valuable adjunct for monitoring patient status since physiological triggers are non-auditory. There are three types of alarms generated by monitoring devices: arrhythmia alarms (change in cardiac rhythm), parameter violation alarms (vital signs that exceed “too low” or “too high” limits, and technical alarms (poor signal quality). Manufacturers set the sensitivity high to avoid the risk of missing a critical signal, but the specificity can be low, thus resulting in many false alarms. In one study of 77 ICU beds in a unit over a one-month period, there were 381,000 audible alarms with an average of 187 alarms per bed per day.[17] There were 12,671 arrhythmia alarms of which 88.8% were false alarms. Desensitization to these incessant alarms has been linked to numerous patient deaths when critical information was ignored. The Joint Commission issued a Sentinel Event Alert in 2013[18] in response to a spate of deaths related to alarm-related sentinel events including alarm fatigue (most common), as well as equipment malfunctions/failures, inadequate training, inadequate staffing, and alarm settings that are not customized to the patients. The strategies to address these problems are multifold and include appropriate responses in high-risk areas, setting alarm limits relevant to the clinical situation, modifying and minimizing alarm use as appropriate, along with adequate training and staffing. Clearly, even though alarm fatigue related to the frequency of false alarms is expected, silencing an alarm is a dangerous response as was seen in this case. Alarms should never be silenced, but instead staff should investigate why an alarm persistently fires and then work to resolve it.

Take-Home Points

- Maternal deaths and severe maternal morbidity remain major challenges in the United States, with rising incidence despite the increasing sophistication of maternity care. It is very problematic that race and ethnic disparities are reflected in maternal deaths and morbidity.
- More than 65% of maternal deaths and morbidity are preventable.
- Use of early maternal warning systems, when linked to standardized checklists and protocols, are key to avoiding poor maternal outcomes.
- Obstetric hemorrhage is a major contributor to poor maternal outcomes but is readily managed when recognized early and is amenable to standardized interventions.
- Alarm fatigue is a well-known result of frequent false alarms from monitoring devices. Adequate staffing and training are critically important in the management of monitoring devices. Alarms should

never be silenced, but instead staff should investigate why an alarm persistently fires and then work to resolve it.

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