Seminars in Perinatology ▮ (2017) ▮▮▮–▮▮▮

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Seminars in Perinatology

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Maternal early warning systems—Towards reducing preventable maternal mortality and severe maternal morbidity through improved clinical surveillance and responsiveness

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ARTICLE INFO

Keywords:
xxx
xxx
xxx

ABSTRACT

Despite increasing awareness of obstetric safety initiatives, maternal mortality and severe maternal morbidity in the United States have continued to increase over the past 20 years. Since results from large-scale surveillance programs suggest that up to 50% of maternal deaths may be preventable, new efforts are focused on developing and testing early warning systems for the obstetric population. Early warning systems are a set of specific clinical signs or symptoms that trigger the awareness of risk and an urgent patient evaluation, with the goal of reducing severe morbidity and mortality through timely diagnosis and treatment. Early warning systems have proven effective at predicting and reducing mortality and severe morbidity in medical, surgical, and critical care patient populations; however, there has been limited research on how to adapt these tools for use in the obstetric population, where physiologic changes of pregnancy render them inadequate. In this article, we review the available obstetric early warning systems and present evidence for their use in reducing maternal mortality and severe maternal morbidity. We also discuss considerations and strategies for implementation and acceptance of these early warning systems for clinical use in obstetrics.

Magnitude of the (preventable) problem

Maternal mortality, defined as the death of a woman during pregnancy, childbirth or within the 42 days after delivery, is a major challenge to health systems worldwide. Over the last century, significant improvements in maternal health have been made throughout the world in places with sufficient access to education and appropriate medical care. Global initiatives have been designed to intensify policy intervention as a response to the growing recognition that primary health care programs in many developing countries were not adequately focused on maternal health.[1] It is well documented that maternal mortality has been increasing in the United States, with CDC data demonstrating a steady increase in pregnancy-related deaths since implementation of the Pregnancy Mortality Surveillance System in 1987.[2] The rising mortality rate is accompanied by an increase in severe maternal morbidity,[3] with significant racial and ethnic

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http://dx.doi.org/10.1053/j.semperi.2017.03.005
0146-0005/

disparities, affecting non-Hispanic black women most severely.[4,5] Unfortunately, international comparisons suggest that the United States has a higher maternal mortality rate than other developed nations,[6] as well as an increasing mortality rate that contrasts worldwide improvement.[7]

Multiple surveillance programs and research initiatives have suggested that up to half of maternal deaths are potentially avoidable, especially those related to hemorrhage, hypertension, infection, and thromboembolic events, which are leading causes of severe maternal morbidity and mortality.[5,8–10] While hemorrhage is the most common cause of maternal death worldwide, it has the lowest case-fatality rate of all causes of maternal mortality, suggesting that most patients do, in fact, survive it. A 2005 statewide review from North Carolina of pregnancy-related deaths found that 93% of deaths from hemorrhage were preventable,[11] and a similar 2002–2003 review from California reported that 69% of deaths from obstetric hemorrhage were found to have had a "good or strong chance to alter the outcome."[12] These reports also found that 60% and 50% of deaths from preeclampsia, 17% and 53% of deaths from venous thromboembolism, and 43% and 50% from sepsis were potentially preventable as well, respectively.[11,12] Overall, these and similar reports suggest that a significant portion of women dying in childbirth in the United States should not be losing their lives and begs the question as to how we can prevent them.

It is well known that physiologic changes of pregnancy lead to alterations in vital signs, clinical symptoms, and laboratory values that can mask, or lead providers to normalize, actual pathology. Additionally, pregnancy typically occurs in young and healthy patients, and is one of the only conditions where women seek medical attention when circumstances are generally expected to go well. The vast majority of parturients presents for care and deliver their babies without significant complication. As such, it is easy to imagine overlooking mild changes in vital and other clinical signs. For example, increased heart rate, mild anemia, and dyspnea are generally accepted as "normal" occurrences in healthy parturients, but these may also be the initial clues to hemorrhage or thromboembolic events. Similarly, borderline platelet levels are common in pregnancy, as are elevated blood pressures in labor, but overlooking this combination of clinical signs could lead to delay in diagnosis and management of HELLP syndrome. In order to prevent severe maternal morbidity and mortality, it is imperative to pay attention to those patients at highest risk for complication. Therefore, development of systems to trigger enhanced surveillance of at-risk patients is essential, and could likely help to avoid delays in diagnosis and intervention for women in clinically dangerous territory.

In the face of increasing severe maternal morbidity and mortality, surveillance efforts have grown in the United States and worldwide. In the United States, leaders from organizations across a wide spectrum of women's health care have come together to form the National Partnership for Maternal Safety.[13] A major goal of this partnership is to reduce preventable morbidity and mortality. One proposed way to accomplish this is to define an obstetric early warning system (EWS) that triggers urgent bedside patient evaluation based on data that indicates an elevated risk for morbidity or mortality.

Use of EWS in non-obstetric populations

Early warning, or trigger systems have been devised, tested, and recommended in non-obstetric populations for the past 2 decades.[14] These tools range from single-parameter systems to multi-parameter, or aggregate-weighted scoring systems, where either a medical provider such as a nurse or a computer algorithm calculates a score based on input of specific data points. In either case, when a critical value or score is reached, bedside patient evaluation is triggered, with the goal of achieving rapid evaluation and initiation of appropriate clinical management of these at-risk patients. In general, aggregate-weighted scoring systems have proved more sensitive than single-parameter ones, and various EWS have been shown to successfully predict patients at highest risk for severe morbidity and mortality in general medicine, surgical, and intensive care unit (ICU) populations. Such scoring systems as the Modified Early Warning Score and Rothman Index vary in their requirements for data entry, ranging from 5 vital signs to 26 discreet data points, but have been shown to be sensitive for predicting severe morbidity (such as ICU admission, hospital readmission, and cardiac arrest) and mortality.[15–19] A systematic review of 21 studies, including data on 13 distinct EWS, reported an excellent ability to predict patients at highest risk of death or cardiac arrest within 48 h, with an area under the receiver operating characteristic curve of >0.85 for all studies/models included.[18] Most importantly, there is a growing body of evidence that EWS not only predict, but also can reduce, severe morbidity and mortality.[20,21]

Obstetric early warning systems

Obstetric EWS are part of a group of clinical tools, which includes bundles, protocols, and checklists, designed to improve patient safety through evidence-based interventions.[22] These tools aim to foster interdisciplinary, patient-centered care to achieve the goal of reduced morbidity and mortality. While the components of EWS vary between models, they all include a list of "triggers" that identify at-risk patients in need of further attention. Beyond identifying patients at risk, EWS inherently include an expectation for continuous surveillance, clearly-defined signals, and a protocol for necessary action by clinical provider once triggered.

Since the most common causes of severe maternal morbidity and mortality are often associated with predictable changes in maternal vital signs, it follows that these may be useful in identifying obstetric patients with impending clinical deterioration. Unfortunately, EWS used in the non-obstetric population have failed to prove useful in obstetric patients.[23] This most likely reflects the physiologic changes of pregnancy, which are not accounted for by original EWS. Until recently, there was a paucity of EWS available for study or use in the obstetric population; however, in response to increasing maternal morbidity and mortality, there has been