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CLINICAL ARTICLE

Baseline assessment of a hospital-specific early warning trigger system for reducing maternal morbidity

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ABSTRACT

Objective: To determine whether predefined maternal early warning triggers (MEWTs) can predict pregnancy morbidity. *Methods:* In a retrospective case–control study, obstetric patients admitted to the intensive care unit (ICU) between 2012 and 2013 at seven pilot US hospitals were compared with control patients who had a normal delivery outcome. Six MEWTs were assessed. *Results:* The case and control groups each contained 50 patients. Hemorrhage (15/50, 30%), sepsis (12/50, 24%), cardiac dysfunction (8/50, 16%), and pre-eclampsia (6/50, 12%) were the most common reasons for ICU admission. Significant associations were recorded between ICU admission and tachycardia (OR 5.0, 95% CI 2.1–11.7), mean arterial pressure less than 65 mm Hg (OR 4.5, 95% CI 1.9–10.8), temperature of at least 38 °C (OR 44.1, 95% CI 13.0–839.1), and altered mental state (OR 44.1, 95% CI 13.1–839.0). Two or more triggers were persistent for 30 minutes or more in 36 (72%) ICU patients versus 2 (4%) controls (OR 61.7, 95% CI 13.2–288.0). Earlier medical intervention might have led to a lesser degree of maternal morbidity for 31 (62%) ICU patients with at least one MEWT. *Conclusion:* Persistent MEWTs were present in most obstetric ICU cases. Retrospectively, MEWTs in this cohort seemed to separate normal obstetric patients from those for whom ICU admission was indicated; their use might reduce maternal morbidity.

1. Introduction

Pregnancy-related maternal deaths in the USA increased by 40% from 12 per 100 000 live births to 16.8 per 100 000 live births between 1998 and 2005 [1]. Recently, the American College of Obstetricians and Gynecologists (ACOG) and the Society for Maternal Fetal Medicine jointly called for US hospitals to adopt safety bundles in reducing maternal morbidity and mortality rates [2]. Similarly in the UK, the Maternal Critical Care Working Group [3] found that, for every maternal death, nine mothers develop severe obstetric complications, including sepsis, massive hemorrhage, hypertensive disorder sequelae, and venothrombotic events. By consensus, the Maternal Critical Care Working Group determined a need for an effective maternal early warning system based on dynamic physiological changes in pregnancy. They envisaged a high-sensitivity system capable of predicting the development of an evolving obstetric complication to prevent significant maternal morbidity and mortality [3].

Maternal vital signs vary widely in pregnancy and commonly reach values that would be considered abnormal in the nonpregnant state [4]. For this reason, an effective bedside early warning trigger system for the nonpregnant population seemed to be inaccurate when used to assess obstetric patients [5]. Studies have demonstrated considerable inconsistency in predicting intensive care unit (ICU) admissions of obstetric patients, particularly regarding the need to call for the provider or rapid response team at the bedside [5–8]. In addition, utilization of non-obstetric scoring systems has failed to accurately identify deteriorating clinical presentations of at-risk obstetric patients [5,7]. For example, the Simplified Physiologic Score System II (SAPS II) was found to predict the subset of obstetric patients with longer ICU stays and increased associated morbidities; however, it overestimated the risk, could not predict obstetric morbidity, and did not correlate with maternal mortality predictions in ICU patients [5]. Similarly, application of Systemic Inflammatory Response Syndrome (SIRS) screening and the Modified Early Warning Score (MEWS) to detect sepsis, clinical deterioration, ICU admission, and impending mortality failed to reliably identify obstetric patients at risk of chorioamnionitis, sepsis, ICU admission, and death [7].

Although most obstetric patients progress through pregnancy, labor, and delivery with few complications, in some cases morbidity seems to increase owing to infrequent recognition or unawareness of evolving maternal signs and symptoms [5,6,8]. Despite the limited success and continued controversy of the practicality of using a bedside, obstetric-specific, maternal warning system [5–8], it might be possible to develop

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a system to decrease obstetric morbidity that is specific to the needs of hospital maternity units.

The present study setting—Dignity Health—is composed of 38 affiliated hospitals in California, Arizona, and Nevada, USA, of which 29 hospitals provide primary to tertiary maternity services with an approximate aggregate total of 60 000 deliveries annually. In this setting, a hospital-specific obstetric early warning trigger system based on maternal signs and symptoms presenting at the time of bedside evaluation—if used to provide timely intervention—would decrease the likelihood of ICU admission and maternal morbidity.

The ability to differentiate low-risk patients from at-risk patients is an essential requirement for testing a screening tool in a prospective fashion [8,9]. After the successful rollout of earlier perinatal safety initiatives [10] and as a continuous quality improvement process, the aim of the present preliminary study was to investigate whether predetermined maternal early warning triggers (MEWTs) can be used to predict an escalating state of morbidity as a first step to reduce maternal morbidity and mortality [2].

2. Materials and methods

In a retrospective case–control study, data were reviewed from obstetric patients admitted to the ICU of seven pilot hospitals of Dignity Health between July 1, 2012, and May 31, 2013. The Dignity Health system Midas quality solution database (Midas + Solutions, Tucson, AZ, USA) was queried to identify all pregnant women admitted to the ICU during the study period. Eligible patients in the case group were at term or preterm with vaginal bleeding, hypertension, abdominal pain, labor, ruptured membranes, fever, gastrointestinal symptoms, and other symptoms requiring evaluation in obstetric triage, were consequently admitted for treatment, and were subsequently transferred to the ICU from the prepartum, intrapartum, and postpartum units. The exclusion criteria were direct admission to the ICU from the emergency department or the operating room, and transferal from other facilities; these patients were not in the maternity unit and were not suitable for retrospective MEWT screening. An equal number of patients admitted to the maternity units after triage with normal delivery outcome over a 24-hour period formed the control group. The retrospective study was exempt from institutional review approval; however, the privacy of patient information was observed in such manner that participants could not be identified directly or indirectly in accordance to the US Health Insurance Portability and Accountability Act.

On the basis of the presenting symptoms and vital sign values in normal pregnancy described in several studies [5–7,11–13], the following MEWTs were assessed: heart rate (HR), including tachycardia (>110 beats per minute) or bradycardia (<50 beats per minute); mean arterial pressure (MAP) less than 65 mm Hg; respiratory rate (RR), including tachypnea (>24 breaths per minute) or bradypnea (<10 breaths per minute); low oxygen saturation (SpO_2 < 94%); abnormal temperature (AT; oral or aural), including high (≥38 °C) or low (<36 °C); and altered mental state (AMS), defined as confusion, agitation, persistent intensifying pain, and/or non-responsiveness. Low or high blood pressure was not included because, first, there are wide variations in low blood pressure that can be considered abnormal in pregnancy [11] and are best addressed by the MAP value; and second, high blood pressure is a component of an established standardized system diagnostic and treatment bundle for hypertension [12,13] in current use as part of the health-system-wide perinatal initiative [10].

A chart level review was performed for all ICU cases in the seven pilot hospitals. Demographic data, vital signs, symptoms, available pertinent notes, and intervention data were evaluated and collated, and then entered into a Microsoft Excel 2010 spreadsheet (Microsoft Corporation, Redmond, WA, USA). The early intervention data included need for blood transfusion, treatment of severe hypertension, starting antibiotics within an hour of sepsis diagnosis, oxygen supplementation, and a call for provider bedside assessment. Matching data were assessed and collected for the control group in a separate database.

The frequency and intervals of observation of MEWTs in the ICU group and control group were compared via Microsoft Excel, and odds ratios (ORs) and 95% confidence intervals (CIs) were generated using MedCalc (MedCalc Software, Ostend, Belgium). $P < 0.05$ was considered to be statistically significant.

3. Results

During the study period, there were 262 ICU cases and 54 429 deliveries in the seven pilot hospitals; thus, the rate of ICU admission was 4.81 per 1000 deliveries. Among the 262 ICU cases, 75 obstetric patients were identified. Twenty-five patients were excluded from the study because they had been admitted directly to the ICU from the emergency department or the operating room, or had been transferred from other facilities. The first 50 patients admitted to the maternity units after triage with normal delivery outcome in a 24-hour period were included in the control group.

The case and control groups had similar characteristics except for length of pregnancy at admission (Table 1), because the control patients were at term and were admitted either in labor or for induction of labor with normal maternal delivery outcome. No patients in either group died. In the ICU group, hemorrhage (15/50, 30%) was the most common reason for admission, followed by sepsis (12/50, 24%), cardiac dysfunction (8/50, 16%), and pre-eclampsia (6/50, 12%). These conditions accounted for 82% of ICU transfers. The remaining 9 (18%) ICU cases were due to diabetic ketoacidosis (n = 4), thromboembolic events (n = 2), and anesthesia complications (n = 3).

There were no patients with bradycardia (HR <50 bpm) or hypothermia (temperature ≤36 °C). The ICU group had a significantly higher frequency of tachycardia as compared with the control group ($P < 0.001$) (Table 2). The mean HR was 130.83 ± 16.34 beats per minute in the ICU group and 107.65 ± 22.28 beats per minute in the control group. The ICU patients also had a higher frequency of MAP less than 65 mm Hg ($P < 0.001$) (Table 2). Mean MAP was 56.00 ± 7.81 mm Hg in the ICU group and 71.01 ± 11.83 mm Hg.

Compared with the control patients, the ICU patients more frequently had a temperature greater than 38 °C ($P < 0.010$) and AMS ($P < 0.001$) (Table 2). Although the frequency of RR greater than 24 breaths per minute was higher in the ICU group, the difference was not significant ($P = 0.078$) (Table 2). The frequency of SpO_2 less than 94% did not differ significantly between the groups ($P = 0.076$) (Table 2).

The presence of two or more MEWTs was seen more frequently in ICU patients than in normal obstetric patients ($P < 0.001$) (Table 3). Of the 10 patients in the control group with at least two MEWTs, the MEWTs did not persist in either the active phase or the second stage

Table 1
Demographic characteristics.[a]

Characteristic	ICU group (n = 50)	Control group (n = 50)	*P* value
Age, y	29.11 ± 6.17	29.73 ± 7.35	0.888[b]
Gravidity	2.86 ± 1.91	2.92 ± 1.96	0.571[b]
Parity	1.42 ± 1.61	1.61 ± 1.66	0.584[b]
Length of pregnancy at admission, wk	34.97 ± 5.44	37.45 ± 2.60	0.002[b]
Ethnic origin			
White	12 (24)	10 (20)	0.316[c]
Black	4 (8)	3 (6)	0.348[c]
Hispanic	22 (44)	21 (42)	0.421[c]
Asian	10 (20)	13 (26)	0.239[c]
Other	2 (4)	3 (6)	0.323[c]

Abbreviation: ICU, intensive care unit.
[a] Values are given as mean ± SD or number (percentage), unless indicated otherwise.
[b] By *t* test.
[c] By *Z*-score test.