Maternal Early Warning Systems

Jill M. Mhyre, MD
Associate Professor of Anesthesiology
Director of Obstetric Anesthesia
The University of Arkansas for Medical Sciences
Disclosure Information

Jill M Mhyre, MD

- I have no financial relationships to disclose.
- I will not discuss any off label uses in my presentation.
Learning Objectives

Upon completion of this activity, the learner will be able to:

1. Recognize the value of an early warning system to identify mothers who might be getting sick
2. Compare the Maternal Early Warning Criteria with the Modified Early Obstetric Warning Score
3. Anticipate implementation consideration for a Maternal Early Warning System
United States Maternal Mortality

Maternal Deaths per 100,000 live births

- Red line: Black
- Dark gray line: All Races *
- Green line: White

Year:
- 1970
- 1975
- 1980
- 1985
- 1990
- 1995
- 2000
- 2005
- 2010
**US Pregnancy-related Mortality**

![Graph showing percentage of deaths by cause of pregnancy-related mortality from 1987 to 2010.](image)

Creanga, Obstet Gynecol 2015
International Comparisons

Maternal Deaths per 100,000 Live Births or Maternities

- Canada (2008): 7.0
- Netherlands (2008): 7.6
- France (2003-07): 8.4
- UK (2006-08): 11.4

Souza JP, et al. BJOG. 2014; 121: 1-4
Creanga et al. Obstet Gynecol. 2015; 125: 5-12
Maternal Deaths with Opportunities for Improvement

<table>
<thead>
<tr>
<th>Country</th>
<th>Maternal Death Rate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>NETHERLANDS</td>
<td>55%</td>
<td>Schutte JM, et al. BJOG. 2010; 117: 399-406</td>
</tr>
<tr>
<td>NEW ZEALAND</td>
<td>37%</td>
<td>Farquhar C, et al. AJOG. 2011; 205: 331e1-8</td>
</tr>
</tbody>
</table>
Pregnancy-Related Mortality in California
Causes, Characteristics, and Improvement Opportunities

Elliott K. Main, MD, Christy L. McCain, MPH, Christine H. Morton, PhD, Susan Holthy, MPH, and Elizabeth S. Lawton, MHS

2002-2005
207 pregnancy related deaths
2,164,457 live-births

Main E, Obstet Gynecol 2015; epub
California Maternal Mortality Ratio 2002-2005, by race

Maternal deaths per 100,000 live births

- Hispanic: 8.5
- Foreign-born: 7.7
- US born: 10
- White: 7.8
- African American: 39.5
- Other: 6.2
- Overall: 9.7

Main E, Obstet Gynecol 2015; epub
Chance to alter the fatal outcome

Main E, Obstet Gynecol 2015; epub
Pregnancy-related deaths due to provider factors by condition
35 year-old woman underwent elective cesarean delivery for prior myomectomy
HR in PACU

- Preoperative HR 110, BP 143/92
- HR range 100-130
Exploratory Laparotomy & Hysterectomy

Cardiac arrest x 2

EBL 18 L
22 U pRBC
17 U FFP
4 x 5 donor pooled plts
1 x 10 donor pooled cryo
Massive Hemorrhage

A Report from the Anesthesia Closed Claims Project

What This Article Tells Us That Is New

- In a review of the past 2 decades of closed anesthesia malpractice claims, two areas (obstetrics and spinal surgery) were overrepresented
- Common to many cases were lack of timely diagnosis, timely transfusion, and reoperation, often reflecting poor team communication

Dutton R, *Anesthesiology* 2014; 121:450-8
Scavone BM, *Anesthesiology* 2014;121:439-41
“In many cases in this report, the early warning signs of impending maternal collapse went unrecognized.”

- **Why?**
  - These events are relatively rare
  - The childbearing population is mostly healthy
  - The normal physiologic changes of pregnancy
MEOWS: Modified Early Obstetric Warning System

“Contact doctor if one red or two yellow scores at any one time.”

Lewis G, Saving Mothers’ Lives, 2007
Sentinel Event Alert

Issue 44, January 26, 2010

Preventing Maternal Death

The goal of all labor and delivery units is a safe birth for both newborn and mother. A previous Alert(1) reviewed the causes of death and injury among newborns with normal birth weight and suggested risk reduction strategies. This Alert addresses the equally tragic loss of mothers.

Common preventable errors include:

- Failure to adequately control blood pressure in hypertensive women
- Failure to adequately diagnose and treat pulmonary edema in women with pre-eclampsia
- Failure to pay attention to vital signs following Cesarean section
- Hemorrhage following Cesarean section

“Too often we under-respond to abnormal vital signs and operate in a state of denial and delay,” Dr. Main says. “It is important to identify triggers and establish protocols that certain findings trigger a response.”
• Have a process for recognizing and responding as soon as a patient’s condition appears to be worsening.

• Develop a written criteria describing early warning signs of a change or deterioration in a patient’s condition and when to seek further assistance.
Maternal Early Warning System

- Identify
- Trigger
- Alert
- Evaluate
- Diagnose
- Respond
- Monitor
Maternal Mortality
Time for National Action

National Partnership for Maternal Safety

Obstet Gynecol 2013;122:735-6
The National Partnership for Maternal Safety
<table>
<thead>
<tr>
<th>Core Patient Safety Bundles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstetric Hemorrhage</td>
</tr>
<tr>
<td>Severe Hypertension in Pregnancy</td>
</tr>
<tr>
<td>Venous Thromboembolism Prevention in Pregnancy</td>
</tr>
<tr>
<td>Supplemental Patient Safety Bundles</td>
</tr>
<tr>
<td>Maternal Early Warning Criteria</td>
</tr>
<tr>
<td>Facility Review</td>
</tr>
<tr>
<td>Family and Staff Support</td>
</tr>
</tbody>
</table>
“What every birthing facility in the US should have...”
Committee Members

Jill Mhyre, Robyn D’Oria, Mary D’Alton, Afshan Hammed, Sharon Holley, Tammy Witmer, Stephen Hunter, Robin Jones, Jeffrey King, Justin Lappen, Janet Meyers
A national survey of obstetric early warning systems in the United Kingdom
Swanton RDJ, IJOA 2009;18:254-7

A validation study of the CEMACH recommended modified early obstetric warning system (MEOWS)*
Singh S, Anaesthesia 2012;67:12-18

Design and internal validation of an obstetric early warning score: secondary analysis of the Intensive Care National Audit and Research Centre Case Mix Programme database
A validation study of the CEMACH recommended modified early obstetric warning system (MEOWS)*

<table>
<thead>
<tr>
<th></th>
<th>Red trigger</th>
<th>Yellow trigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature; °C</td>
<td>&lt; 35 or &gt; 38</td>
<td>35–36</td>
</tr>
<tr>
<td>Systolic BP; mmHg</td>
<td>&lt; 90 or &gt; 160</td>
<td>150–160 or 90–100</td>
</tr>
<tr>
<td>Diastolic BP; mmHg</td>
<td>&gt; 100</td>
<td>90–100</td>
</tr>
<tr>
<td>Heart rate; beats.min⁻¹</td>
<td>&lt; 40 or &gt; 120</td>
<td>100–120 or 40–50</td>
</tr>
<tr>
<td>Respiratory rate; breaths.min⁻¹</td>
<td>&lt; 10 or &gt; 30</td>
<td>21–30</td>
</tr>
<tr>
<td>Oxygen saturation; %</td>
<td>&lt; 95</td>
<td>–</td>
</tr>
<tr>
<td>Pain score</td>
<td>–</td>
<td>2–3</td>
</tr>
<tr>
<td>Neurological response</td>
<td>Unresponsive, pain</td>
<td>Voice</td>
</tr>
</tbody>
</table>

673/676 had a MEOWS chart
200 (30%) triggered an evaluation

Singh S, Anaesthesia 2012;67:12-18
- Pulmonary embolism
- Cerebral venous sinus thrombosis
- Intracranial bleed

86 patients (13%)

- DKA
- Myocardial infarction
- Pulmonary edema
- Status epilepticus

Singh S, Anaesthesia 2012;67:12-18
Results

- 673 patients scored
- 200 (30%) triggered an evaluation
- 86 (13%) met criteria for morbidity
- Sensitivity 89%
- Specificity 79%
- Positive Predictive Value 39%
- Negative Predictive Value 98%

Singh S, Anaesthesia 2012;67:12-18
Committee Members

Jill Mhyre, Robyn D’Oria, Mary D’Alton, Afshan Hammed, Sharon Holley, Tammy Witmer, Stephen Hunter, Robin Jones, Jeffrey King, Justin Lappen, Janet Meyers
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Red trigger</th>
<th>Yellow trigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature; °C</td>
<td>&lt; 35 or &gt; 38</td>
<td>35–36</td>
</tr>
<tr>
<td>Systolic BP; mmHg</td>
<td>&lt; 90 or &gt; 160</td>
<td>150–160</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 90–100</td>
</tr>
<tr>
<td></td>
<td>&gt; 100</td>
<td>90–100</td>
</tr>
<tr>
<td></td>
<td>&lt; 40 or &gt; 120</td>
<td>100–120</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 40–50</td>
</tr>
<tr>
<td></td>
<td>&lt; 10 or &gt; 30</td>
<td>21–30</td>
</tr>
<tr>
<td>Diastolic BP; mmHg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart rate; beats.min⁻¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 95</td>
<td></td>
</tr>
<tr>
<td>Respiratory rate; breaths.min⁻¹</td>
<td>Unresponsive, pain</td>
<td></td>
</tr>
<tr>
<td>Oxygen saturation; %</td>
<td></td>
<td>2–3</td>
</tr>
<tr>
<td>Pain score</td>
<td></td>
<td>Voice</td>
</tr>
<tr>
<td>Neurological response</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- Patient with hypertension reporting a non-remitting headache
- Patient with preeclampsia or hypertension reporting shortness of breath

Obstet Gynecol 2012;119:360-4
# The Maternal Early Warning Criteria

*A Proposal From the National Partnership for Maternal Safety*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic BP (mm Hg)</td>
<td>&lt;90 or &gt;160</td>
</tr>
<tr>
<td>Diastolic BP (mm Hg)</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Heart rate (beats per min)</td>
<td>&lt;50 or &gt;120</td>
</tr>
<tr>
<td>Respiratory rate (breaths per min)</td>
<td>&lt;10 or &gt;30</td>
</tr>
<tr>
<td>Oxygen saturation on room air, at sea level, %</td>
<td>&lt;95</td>
</tr>
<tr>
<td>Oliguria, mL/hr for ≥2 hours</td>
<td>&lt;35</td>
</tr>
<tr>
<td>Maternal agitation, confusion, or unresponsiveness; Patient with preeclampsia reporting a non-remitting headache or shortness of breath</td>
<td></td>
</tr>
</tbody>
</table>

---

Mhyre JM, Obstet Gynecol 2014; 124:782-6
Clark SL, Obstetrics & Gynecology, 2012; 119: 360-3648
Maternal Early Warning System

- Monitor
- Identify
- Trigger
- Alert
- Evaluate
- Diagnose
- Respond

Maternal Early Warning Criteria
Case Illustration

- 34 year old recovering from cesarean delivery in the PACU
- Nausea, vomiting, diaphoresis
Measurement Artifact

• A single abnormal vital sign can reflect measurement artifact

• **Verify isolated abnormal measurements**
  – HR, BP, RR, SpO₂

• **Urgent bedside evaluation is usually indicated if:**
  – Any value persists for more than one measurement
  – Values present in combination with additional abnormal parameters
  – Value recurs more than once

Mhyre JM, Obstet Gynecol 2014; 124:782-6
Immediate Action Required

- Systolic BP; mmHg <90 or >160
- Diastolic BP; mmHg >100
- Heart rate; bpm <50 or >120
- Respiratory rate; bpm <10 or >30
- Oxygen saturation; % <95
- Oliguria; ml/hr x 2h <35

- Maternal agitation, confusion, or unresponsiveness
- Patient with hypertension reporting a non-remitting headache or shortness of breath

Mhyre JM, Obstet Gynecol 2014; 124:782-6
Effective Escalation Policy

An abnormal parameter would require:

1. Prompt reporting to a physician or other qualified clinician

2. Prompt bedside evaluation by a physician or other qualified clinician with the ability to activate resources in order to initiate emergency diagnostic and therapeutic interventions as needed

Mhyre JM, Obstet Gynecol 2014; 124:782-6
Alert Considerations

Need to define:

1. Who to notify
2. How to notify them
3. How rapidly to expect a response
4. When and how to activate the clinical chain of command in order to ensure an appropriate response
Why Bedside Evaluation

• Maternal mortality reviews repeatedly identify the lethal consequences of phone-based management in women developing critical illness
Evaluating Clinician

- Anesthesiologist
- Nurse/Anesthetist
- Emergency Physician
- Patient
- Primary Obstetric Provider
- Bedside Nurse
- Rapid Response Team
- MFM Laborist/Family MD
- Nurse/Midwife
- Hospitalist/Intensivist
Differential Diagnoses

- Hypertension (SBP>160 or DBP>100)
- Hypotension (SBP<90)
- Tachycardia (HR>120)
- Bradycardia (HR<50)
- Tachypnea (RR>30)
- Bradypnea (RR<10)
- Hypoxemia (SpO₂ <95% on room air)
- Oliguria (<35 ml/hr for >2 hrs)

links.lww.com/AOG/A551
Tachycardia (HR>120)

Common
- Dehydration
- Hemorrhage
- Infection
- Medication effects
- Anxiety
- Pain

Rare life-threatening
- Cardiac
- Illicit substances
- Pulmonary embolism
- Concealed hemorrhage
- Amniotic fluid embolism
- Anaphylaxis
- Endocrine disorders
- Malignant hyperthermia
- Vascular emergency

Mhyre JM, Obstet Gynecol 2014; 124:782-6
What are appropriate outcomes for a bedside evaluation?

When the bedside evaluation is non-diagnostic, or when clinicians suspect that a particular warning criterion reflects normal physiology for that patient

Establish a tailored plan for subsequent monitoring, notification and clinical review
Recurrent Maternal Early Warning Criteria

- Increase the intensity and frequency of monitoring
- Increase the frequency of evaluation
- Initiate resuscitative and diagnostic interventions
- Carefully consider the appropriate differential until a diagnosis is confirmed, or until the criteria resolve
Diagnosed as critically ill or a high likelihood of developing critical illness

- Initiate appropriate resuscitative, diagnostic and therapeutic interventions
- Escalate level of care
  - Obstetric emergency response teams
  - Rapid response teams
  - Transfer to a higher acuity setting
MEOWS: Modified Early Obstetric Warning System

“Contact doctor if one red or two yellow scores at any one time.”

Lewis G, Saving Mothers’ Lives, 2007
December 2012

100% of respondents use an EWS (n=130)
- CEMD recommended MEOWS chart – 45%
- Modified version of MEOWS — 50%
- Different system — 5%

118 agreed the EWS helped prevent obstetric morbidity (91%)

Isaacs RA, Anaesthesia 2014;69:687-92
A national survey of obstetric early warning systems in the United Kingdom: five years on

<table>
<thead>
<tr>
<th>Subset of women</th>
<th>Yes</th>
<th>No</th>
<th>N/A or blank</th>
</tr>
</thead>
<tbody>
<tr>
<td>All women after surgery</td>
<td>116 (89%)</td>
<td>4 (3%)</td>
<td>10 (8%)</td>
</tr>
<tr>
<td>Women in the high dependency unit</td>
<td>105 (81%)</td>
<td>6 (5%)</td>
<td>19 (14%)</td>
</tr>
<tr>
<td>All women admitted to the consultant-led unit</td>
<td>109 (84%)</td>
<td>19 (14%)</td>
<td>2 (2%)</td>
</tr>
<tr>
<td>Women in the midwife-led unit</td>
<td>49 (38%)</td>
<td>27 (21%)</td>
<td>54 (41%)</td>
</tr>
<tr>
<td>High-risk women only</td>
<td>26 (20%)</td>
<td>39 (30%)</td>
<td>65 (50%)</td>
</tr>
<tr>
<td>Antenatal/postnatal women in the community</td>
<td>21 (16%)</td>
<td>59 (45%)</td>
<td>50 (39%)</td>
</tr>
</tbody>
</table>
Irish Maternity Early Warning System (IMEWS)
Escalation Guideline

ALL IMEWS TRIGGERS
Consider context and complete full clinical assessment. Implement measures to reduce triggers if appropriate. Complete a full set of observations on IMEWS immediately. Inform the Midwife in charge.

1 YELLOW
Repeat full set of observations on IMEWS after 30 and before 60 minutes.

2 YELLOWS OR 1 PINK
Call the obstetrician to review. Repeat a full set of observations after 30 minutes.

>2 YELLOWS OR >2 PINKS
Call the obstetrician and request immediate review. Repeat a full set of observations within 15 minutes or monitor continuously.

ALL IMEWS TRIGGERS
Discuss with the Midwife in charge. Document all communication including:
- Redefined plan of care
- Ongoing frequency of observations

CONSIDER MATERNAL SEPSIS

AND

If infection is suspected after medical review

**Intervention: within one hour COMPLETE SEPSIS SIX**

<table>
<thead>
<tr>
<th>SIRS criteria present?</th>
<th>AND</th>
<th>Intervention: within one hour COMPLETE SEPSIS SIX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature ≥38°C or ≤36°C</td>
<td>1.</td>
<td>1. Appropriate cultures*</td>
</tr>
<tr>
<td>Respiratory rate ≥20 breaths per min</td>
<td>2.</td>
<td>2. P3C +/- lactate</td>
</tr>
<tr>
<td>Heart rate ≥100 beats per min</td>
<td>3.</td>
<td>3. Start utero output chart</td>
</tr>
<tr>
<td>White cell count &gt;16.9 or ≤4.0 x 10^9/L</td>
<td>4.</td>
<td>4. Maintain O2 (94-98%)</td>
</tr>
<tr>
<td>Ostracide glucose &gt;7.7 mmol/L (in the absence of diabetes)</td>
<td>5.</td>
<td>5. Consider IV fluid bolus**</td>
</tr>
<tr>
<td>Acute altered mental status</td>
<td>6.</td>
<td>6. IV antibiotics</td>
</tr>
</tbody>
</table>

*example: blood, wound, vaginal swab, urine etc
**exercise caution in presence of pre-existing diabetes

Design and internal validation of an obstetric early warning score: secondary analysis of the Intensive Care National Audit and Research Centre Case Mix Programme database

<table>
<thead>
<tr>
<th></th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Systolic blood pressure (mmHg)</strong></td>
<td>&lt; 80</td>
<td>80–89</td>
<td>90–139</td>
<td>140–149</td>
<td>150–159</td>
<td>≥ 160</td>
<td></td>
</tr>
<tr>
<td><strong>Diastolic blood pressure (mmHg)</strong></td>
<td></td>
<td></td>
<td></td>
<td>&lt; 90</td>
<td>90–99</td>
<td>100–109</td>
<td>≥ 110</td>
</tr>
<tr>
<td><strong>Respiratory rate (min⁻¹)</strong></td>
<td>&lt; 10</td>
<td>10–17</td>
<td>18–24</td>
<td>25–29</td>
<td></td>
<td></td>
<td>≥ 30</td>
</tr>
<tr>
<td><strong>Heart rate (min⁻¹)</strong></td>
<td>&lt; 60</td>
<td>60–110</td>
<td></td>
<td></td>
<td>111–149</td>
<td></td>
<td>≥ 150</td>
</tr>
<tr>
<td><strong>% O₂ required to maintain SpO₂ ≥ 96%</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Room air</td>
<td>24–39%</td>
<td>≥ 40%</td>
</tr>
<tr>
<td><strong>Temperature (°C)</strong></td>
<td>&lt; 34.0</td>
<td>34.0–35.0</td>
<td>35.1–37.9</td>
<td>38.0–38.9</td>
<td></td>
<td></td>
<td>≥ 39</td>
</tr>
<tr>
<td><strong>Conscious level</strong></td>
<td></td>
<td></td>
<td></td>
<td>Alert*</td>
<td></td>
<td></td>
<td>Not alert†</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Score trigger</th>
<th>Graded response</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td><strong>Routine</strong></td>
</tr>
<tr>
<td></td>
<td>minimum 12 hourly observations</td>
</tr>
<tr>
<td>1-3 (aggregate)</td>
<td><strong>Low</strong></td>
</tr>
<tr>
<td></td>
<td>minimum 4 hourly observations</td>
</tr>
<tr>
<td></td>
<td>alert nurse in charge</td>
</tr>
<tr>
<td>One parameter scores ‘3’†</td>
<td><strong>Medium</strong></td>
</tr>
<tr>
<td>or ≥4 (aggregate)</td>
<td>minimum 1 hourly observations</td>
</tr>
<tr>
<td></td>
<td>urgent call to the medical team caring for the patient and to</td>
</tr>
<tr>
<td></td>
<td>personnel with competencies for acute illness</td>
</tr>
<tr>
<td>≥6 (aggregate)</td>
<td><strong>High</strong></td>
</tr>
<tr>
<td></td>
<td>continuous monitoring of vital signs</td>
</tr>
<tr>
<td></td>
<td>emergency call to a team with critical care competencies and</td>
</tr>
<tr>
<td></td>
<td>diagnostic skills</td>
</tr>
</tbody>
</table>

Virtual Sepsis Unit Aids Early Detection

by David Wild

A “virtual sepsis unit,” constructed from ones and zeros, may help speed the identification of severe sepsis or septic shock in patients outside the ICU, new findings suggest.

During a three-month pilot study conducted at Mercy Hospital St. Louis, in Missouri, the telemedicine-based system identified all hospitalized patients who developed the complication, according to the researchers, who presented the findings at the 2014 annual meeting of the Society of Critical Care Medicine (poster 1026).
Maternal Early Warning Criteria

Systolic BP; mmHg <90 or >160
Diastolic BP; mmHg >100
Heart rate; bpm <50 or >120
Respiratory rate; bpm <10 or >30
Oxygen saturation; % <95
Oliguria; mL/hr x 2h <35

- Maternal agitation, confusion, or unresponsiveness
- Patient with hypertension or preeclampsia reporting a non-remitting headache or shortness of breath

Mhyre JM, Obstet Gynecol 2014; 124:782-6
Maternal Early Warning System

- Monitor
- Identify
- Trigger
- Respond
- Diagnose
- Evaluate
- Alert
References


