OBSTETRICS

Measuring severe maternal morbidity: validation of potential measures

Elliott K. Main, MD; Anisha Abreo, MPH; Jennifer McNulty, MD; William Gilbert, MD; Colleen McNally, MD; Debra Poeltler, PhD; Katarina Lanner-Cusin, MD; Douglas Fenton, MD; Theresa Gipps, MD; Kathryn Melsop, MS; Naomi Greene, PhD; Jeffrey B. Gould, MD, MPH; Sarah Kilpatrick, PhD, MD

BACKGROUND: Both maternal mortality rate and severe maternal morbidity rate have risen significantly in the United Sates. Recently, the Centers for Disease Control and Prevention introduced International Classification of Diseases, 9th revision, criteria for defining severe maternal morbidity with the use of administrative data sources; however, those criteria have not been validated with the use of chart reviews.

OBJECTIVE: The primary aim of the current study was to validate the Centers for Disease Control and Prevention International Classification of Diseases, 9th revision, criteria for the identification of severe maternal morbidity. This analysis initially required the development of a reproducible set of clinical conditions that were judged to be consistent with severe maternal morbidity to be used as the clinical gold standard for validation. Alternative criteria for severe maternal morbidity were also examined.

STUDY DESIGN: The 67,468 deliveries that occurred during a 12-month period from 16 participating California hospitals were screened initially for severe maternal morbidity with the presence of any of 4 criteria: (1) Centers for Disease Control and Prevention International Classification of Diseases, 9th revision, diagnosis and procedure codes; (2) prolonged postpartum length of stay (>3 standard deviations beyond the mean length of stay for the California population); (3) any maternal intensive care unit admissions (with the use of hospital billing sources); and (4) the administration of any blood product (with the use of transfusion service data). Complete medical records for all screen-positive cases were examined to determine whether they satisfied the criteria for the clinical gold standard (determined by 4 rounds of a modified Delphi technique). Descriptive and statistical analyses that included area under the receiver operating characteristic curve and C-statistic were performed.

RESULTS: The Centers for Disease Control and Prevention International Classification of Diseases, 9th revision, criteria had a reasonably high sensitivity of 0.77 and a positive predictive value of 0.44 with a C-statistic of 0.87. The most important source of false-positive cases were mothers whose only criterion was 1-2 units of blood products. The Centers for Disease Control and Prevention International Classification of Diseases, 9th revision, criteria screen rate ranged from 0.51-2.45% among hospitals. True positive severe maternal morbidity ranged from 0.05-1.13%. When hospitals were grouped by their neonatal intensive care unit level of care, severe maternal morbidity rates were statistically lower at facilities with lower level neonatal intensive care units ($P < .0001$).

CONCLUSION: The Centers for Disease Control and Prevention International Classification of Diseases, 9th revision, criteria can serve as a reasonable administrative metric for measuring severe maternal morbidity at population levels. Caution should be used with the use of these criteria for individual hospitals, because case-mix effects appear to be strong.

Key words: Centers for Disease Control and Prevention, maternal morbidity rate, severe maternal morbidity

Over the last 15 years both maternal mortality and morbidity rates have risen significantly in the United States.[1-3] Despite the increasing rate, maternal mortality remains a rare event and difficult to track in a timely manner. Depending on the definition, severe maternal morbidity occurs 50-100 times more frequently than death and identifies cases that were on a pathway to death.[3-5] A measure of severe maternal morbidity based on administrative data would provide rapid assessments of maternal health at both hospital and population levels and track progress of large-scale care-improvement projects.

Kuklina et al[6] and Geller et al[7] established criteria for identification of "near miss" maternal morbidity at the hospital level focusing on maternal intensive care unit (ICU) admission or transfusion of ≥4 units of any blood product.[6,7] These criteria were validated[8] and proposed for national use for internal hospital quality reviews (with the slight revision of ≥4 units of red blood cells).[9,10] Unfortunately, these criteria are not present in administrative data sets that would prevent their use for population-level assessments. In contrast, investigators at the Centers for Disease Control and Prevention (CDC) used a set of International Classification of Disease, 9th Edition, Clinical Manual (ICD-9 CM) diagnosis and procedure codes that are associated with maternal death to identify potential cases of severe maternal morbidity (referred to as CDC ICD-9 criteria; Table 1).[3-5] However, the accuracy of the CDC ICD-9 criteria in the identification of women with true severe maternal morbidity has not been evaluated with the use of actual patient records. The primary aim of the current study was to validate the CDC ICD-9 criteria in the identification of severe maternal morbidity by reviewing medical records from a large representative sample of cases picked up by the CDC ICD-9 criteria. This analysis required the development of a reproducible set of clinical conditions that were judged

Cite this article as: Main EK, Abreo A, McNulty J, et al. Measuring severe maternal morbidity: validation of potential measures. Am J Obstet Gynecol 2016;●●●:●●●●.

0002-9378/$36.00

http://dx.doi.org/10.1016/j.ajog.2015.11.004

FLA 5.4.0 DTD ■ YMOB10772_proof ■ 15 December 2015 ■ 10:30 pm ■ ce

TABLE 1
Severe maternal morbidity indicators and corresponding International Classification of Diseases, 9th revision, Clinical Modification codes that were developed by the Centers for Disease Control and Prevention[a]

Indicator	Code
Acute myocardial infarction	410.xx
Acute renal failure	584.x, 669.3x, 277.88[b]
Adult respiratory distress syndrome	518.5, 518.81, 518.82, 518.84,799.1
Amniotic fluid embolism	673.1x
Aneurysm	441.xx
Cardiac arrest/ventricular fibrillation	427.41, 427.42, 427.5
Disseminated intravascular coagulation	286.6, 286.9, 666.3x
Eclampsia	642.6x
Heart failure during procedure or surgery	669.4x, 997.1
Internal injuries of thorax, abdomen, and pelvis	860.xx-869.xx
Intracranial injuries	800.xx, 801.xx, 803.xx, 804.xx, 851.xx-854.xx
Puerperal cerebrovascular disorders	430, 431, 432.x, 433.xx, 434.xx, 436, 437.x, 671.5x, 674.0x, 997.2, 999.2
Pulmonary edema	428.1, 518.4
Severe anesthesia complications	668.0x, 668.1x, 668.2x
Sepsis	038.xx, 995.91, 995.92, 670.2[b]
Shock	669.1x, 785.5x, 995.0, 995.4, 998.0
Sickle cell anemia with crisis	282.62, 282.64, 282.69
Thrombotic embolism	415.1x, 673.0x, 673.2x, 673.3x, 673.8x
International Classification of Diseases, 9th revision, Clinical Modification procedure codes	
Blood transfusion	99.0x
Cardio monitoring	89.6x
Conversion of cardiac rhythm	99.6x
Hysterectomy	68.3x-68.9
Operations on heart and pericardium	35.xx, 36.xx, 37.xx, 39.xx
Temporary tracheostomy	31.1
Ventilation	93.90, 96.01-96.05, 96.7x

[a] Available at: http://www.cdc.gov/reproductivehealth/MaternalInfantHealth/SevereMaternalMorbidity.html (accessed: ••••); [b] Two additional codes (277.88 and 670.2) were added to the codes published on the Centers for Disease Control and Prevention website; federally available data resource document (available at: http://mchb.hrsa.gov/blockgrant/fadresourcedocument.pdf. Accessed, June 30, 2015).

Main et al. Validation of severe maternal morbidity measures. Am J Obstet Gynecol 2016.

to be consistent with severe maternal morbidity and hence used as the clinical gold standard for determination of true severe maternal morbidity. The CDC ICD-9 criteria and "Gold Standard" rates of severe maternal morbidity will then be compared among hospital levels of care. A secondary aim was to identify any ICD-9 or procedure code additions or deletions that could improve the CDC ICD-9 criteria.

Methods

Our study sample included all mothers who delivered at >20 weeks of gestation from July 1, 2012, through June 30, 2013, from 16 participating hospitals that were representative of all regions of California (including urban and suburban) and all levels of neonatal intensive care. We intentionally sought a higher representation of regional perinatal centers and hospitals with a greater percentage of African American births to reflect a wide range of cases with severe maternal mortality rates. We used 4 screening strategies initially to identify cases of potential severe maternal morbidity for chart review. These included all mothers with any of the following events: (1) CDC ICD-9 diagnosis and procedure codes, (2) prolonged postpartum length of stay (PPLOS) defined as 3 standard deviations beyond the mean length of stay for the California population (4 days for a vaginal delivery; 6 days for a cesarean delivery), (3) any maternal ICU admissions, and (4) administration of any blood product. The first 2 screening criteria used data from the California Maternal Data Center that linked patient discharge diagnosis data with birth certificate data; the other screening methods (ICU and blood administration) used alternate hospital data sources (chargemaster files, admission discharge transfer files, and blood bank data systems). Only data from the birth admission were analyzed because antenatal and postpartum admissions were more difficult to identify reliably in our data sets.

The case review team was comprised of 10 obstetric researchers who were experienced in quality reviews, several of whom had specific experience in assessment of severe maternal morbidity. The team first developed a set of consensus clinical conditions to establish a "gold standard" to identify severe maternal morbidity. This process started with previously established criteria that included near miss and organ failure and expanded to severe temporary harm and additional significant procedures.[6,7] We incorporated a patient-orientated view that focused on complications that have significant impact on the woman and her family. Consensus was developed with a modified Delphi method.[11] Some clinical conditions, typically those that were "near miss,"[6] reached immediate consensus, but others required more discussion. To build consistency among

FLA 5.4.0 DTD ■ YMOB10772_proof ■ 15 December 2015 ■ 10:30 pm ■ ce