Critical care in obstetrics: a strategy for addressing maternal mortality

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The acute rise in maternal morbidity and mortality in the United States is in part because of an increasingly medically complex obstetrical population. An estimated 1% to 3% of all obstetrical patients require intensive care, making timely delivery and availability of critical care imperative. The shifting landscape in obstetrical acuity places a burden on obstetrical providers, many of whom have limited experience in identifying and responding to critical illness. The levels of maternal care definitions by the American College of Obstetricians and Gynecologists and the Society for Maternal-Fetal Medicine designate hospitals based on the availability of obstetrical resources and highlight the need for critical care resources and expertise. The growing need for critical care skills in the evolving contemporary obstetrical landscape serves as an opportunity to redefine the concept of delivery of care for high-risk obstetrical patients. We summarized the key tenets in the prevention of maternal morbidity and mortality, including the use of evidence-based tools for risk stratification and timely referral of patients to facilities with appropriate resources; innovative pathways for hospitals to provide critical care consultations on labor and delivery; and training of obstetrical providers in high-yield critical care skills, such as point-of-care ultrasonography. These critical care—focused interventions are key in addressing an increasingly complex obstetrical patient population while providing an educational foundation for the training of future obstetrical providers.

Key words: critical care, maternal critical care, obstetric comorbidity index, obstetrical critical care, point-of-care ultrasound, screening tools

Introduction

The acute rise in maternal mortality in the United States is in part because of an increasing medically complex obstetrical population.[1,2] Severe maternal morbidity—defined as unexpected outcomes of labor and delivery that result in significant short- or long-term consequences to a woman's health—has increased 200% from 1993 to 2014.[3] Equally concerning is the preventability of maternal death. In a recent review, 60% of maternal deaths were preventable, highlighting the need for clinical awareness, appropriate evaluation, timely diagnosis, and early intervention in high-risk obstetrical patients.[1]

Critical care providers specialize in the medical treatment and monitoring of patients at risk of developing end-organ dysfunction.[4] An estimated 1% to 3% of all obstetrical patients require intensive care unit (ICU) level care, making the delivery and availability of critical care imperative.[5] The levels of maternal care definitions by the American College of Obstetricians and Gynecologists and the Society for Maternal-Fetal Medicine (SMFM) stratify hospitals based on the availability of obstetrical resources and highlight the need for critical care resources and expertise within this framework.[6] The landmark article by D'Alton et al,[7] published nearly 10 years ago, provided a paradigm "shift" in our approach and perception of high-risk obstetrical patients. In this article, critical care education for maternal-fetal medicine (MFM) specialists and the

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standardization of management of patients who are critically ill, such as those with cardiac disease, were listed as core strategies to combat maternal morbidity and mortality. This call has been met with enthusiasm within MFM, but the growing need for critical care skills and resources, coupled with the scarcity of MFM specialists in some settings, serves as an opportunity to redefine the concept of the delivery of critical care for high-risk obstetrical patients for all obstetrical trainees and staff.[8,9]

We outline the need for critical care services on labor and delivery while offering a pragmatic solution for an increasingly complex obstetrical population. We highlight the importance of using evidence-based tools for risk stratification and rapid diagnosis of cardiopulmonary dysfunction, a pathway for hospitals to provide critical care consultations on labor and delivery while providing an educational foundation for students, residents, staff, and other obstetrical providers caring for high-risk patients.

Screening Tools for High-Risk Patients

The creation of "scoring tools" for the timely identification of obstetrical patients at risk of clinical decompensation has been identified as an essential strategy by leading experts in addressing maternal morbidity and mortality.[10] In 2014, the National Partnership for Maternal Safety recommended the use of evidence-based screening tools, such as the Modified Early Warning System (MEWS), predictive of clinical deterioration in the obstetrical setting.[11] In 2017, the SMFM assembled a group to evaluate the use of MEWS in practice.[11,12] The group concluded that integrating these tools into an electronic medical record and having an early warning system were identified as essential ways to optimize capturing patients at risk of clinical deterioration.[11] Although early warning systems may help identify the patients at risk for developing morbidity, physiological-based screening tools, such MEWS, lack specificity for identifying obstetrical patients' at risk of clinical deterioration.[13] In addition, physiological changes in pregnancy and those during the peripartum period, such as intermittent tachycardia and tachypnea, pose a particular challenge in using vital signs in the identification of high-risk patients and prediction of clinical deterioration.

A screening tool, which has shown promise in predicting critical illness in obstetrical patients, is the sequential organ failure assessment (SOFA) score, a widely used screening tool in critical care that assesses end-organ dysfunction.[14] The transition from using vital sign-based only screening tools (MEWS) to using screening tools with end-organ and comorbidity assessments (SOFA) signals a paradigm shift in the approach to identifying critical illness in obstetrics. This evolution mirrors the shift seen also in critical care medicine, where vital signs—based screening tools (systemic inflammatory response syndrome) are no longer recommended and are being replaced by tools focused on end-organ dysfunction (SOFA).[15]

The development of screening tools that focus on identifying end-organ dysfunction and comorbidities have recently shown promise in predicting clinical deterioration in the obstetrical setting. The obstetric comorbidity index (OB-CMI) is a validated tool that incorporates a patient's comorbidity burden and is used to identify women at risk of severe maternal morbidity (Figure 1; Video 1).[16,17] By summarizing multiple medical conditions into a single number, the OB-CMI represents a screening mechanism for providing targeted high-risk care while reducing the risk of "alarm fatigue" observed with other physiological screening tools. The incidence of severe maternal morbidity increases with a rise in OB-CMI score, reflective of a patient's comorbidity burden.[16] In a prospective study by Easter et al[16] examining 2828 obstetrical patients, the authors found that a score of "0" was associated with <1% incidence of ICU level care (severe maternal morbidity), compared with a 12% to 14% incidence of ICU level care with a score of "7." Every 1 point increase in the OB-CMI score was associated with a 1.55 increase in odds in a patient developing severe maternal morbidity (Figure 2).

Validated screening tools, such as the OB-CMI, identify a patient's comorbidity burden and can help facilitate the identification of high-risk patients warranting transfer to hospitals with appropriate resources. A recently published national population-based study in Denmark examining over 800,000 pregnancies used the OB-CMI to analyze the discriminatory and predictive ability of morbidity and death.[17] The screening tool was able to show the value in predicting end-organ dysfunction, morbidity, and death. The authors ultimately concluded that the OB-CMI could serve to "clinically identify women at high-risk for adverse maternal outcomes." Similarly, a recent study in the United States showed that using the OB-CMI was superior compared with conventional risk identification methods in identifying patients with severe maternal morbidity or mortality.[18] An "expanded" comorbidity index, which builds on the OB-CMI, was recently developed to predict severe maternal morbidity and nontransfusion maternal morbidity.[19] Although the OB-CMI was expanded, it is yet to be validated prospectively; furthermore, the emphasis toward risk assessment based on a patient's comorbidity burden marks a fundamental shift in the clinical approach to high-risk obstetrical patients. The tracking of comorbidity burden across hospital networks can facilitate the transfer of previously undetected high-risk obstetrical patients to facilities with proper resources (level III to level IV transfer), a recommendation by the levels of maternal care consensus guidelines.

The incorporation of validated comorbidity indexes, such as the OB-CMI, allows for heightened electronic surveillance and potential identification of previously undetected high-risk patients in both the antenatal and inpatient settings. Antepartum comorbidity-based risk prediction systems have a further advantage over intrapartum physiology-based tools as they allow for risk-appropriate care before the development of a hemodynamically unstable

FIGURE 1
Obstetric comorbidity index

Obstetric Comorbidity Index Score

Patient Sticker Here

Maternal Condition	Points	Comments
Preeclampsia with Severe Features* or Eclampsia	5	
Preeclampsia / Gestational / Chronic Hypertension	2	
Congestive Heart Failure	5	
Pulmonary Hypertension	4	
Ischemic Heart Disease / Cardiac Arrhythmia	3	
Congenital Heart and/or Valvular Disease	4	
Multiple Gestation	2	
Intrauterine Fetal Demise	2	
Placenta Previa / Suspected Accreta / Abruption	4	
Previous Cesarean Delivery / Myomectomy	1	
Autoimmune Disease / Lupus	2	
HIV/AIDS	2	
Sickle Cell Disease / Bleeding Disorder / Coagulopathy / Anticoagulation	3	
Epilepsy / Cerebrovascular Accident / Neuromuscular Disorder	2	
Chronic Renal Disease	1	
Asthma	1	
Diabetes on Insulin	1	
Maternal Age > 44	3	
Maternal Age 40-44	2	
Maternal Age 35-39	1	
Substance Use Disorder	2	
Alcohol Abuse	1	
BMI > 50	3	
BMI > 40	2	
*__Severe Features__: Systolic BP ≥ 160, diastolic BP ≥ 110, creatinine > 1.1, oliguria (<30 cc/hr), elevated AST or ALT, platelets < 100,000, persistent epigastric pain, headache, or scotomata, placental abruption.	**Total:**	**MD Notified:**

Instructions for Use:

1) Circle comorbidities present in your patient and tally score at bottom.
2) Does this patient have any other high-risk features you think should be added to the list? _____
3) Notify Responding Clinician for patients with OB-CMI score > 6 or with any other concerns.
4) Document the OB-CMI score in the nursing handoff template.
5) Place completed sheet in locked bin behind desk.

RN _____ Date _____ Time _____

Adapted from Easter et al.[16]

ALT, alanine transaminase; *AST*, aspartate aminotransferase; *BMI*, body mass index; *BP*, blood pressure; *OB-CMI*, obstetric comorbidity index.

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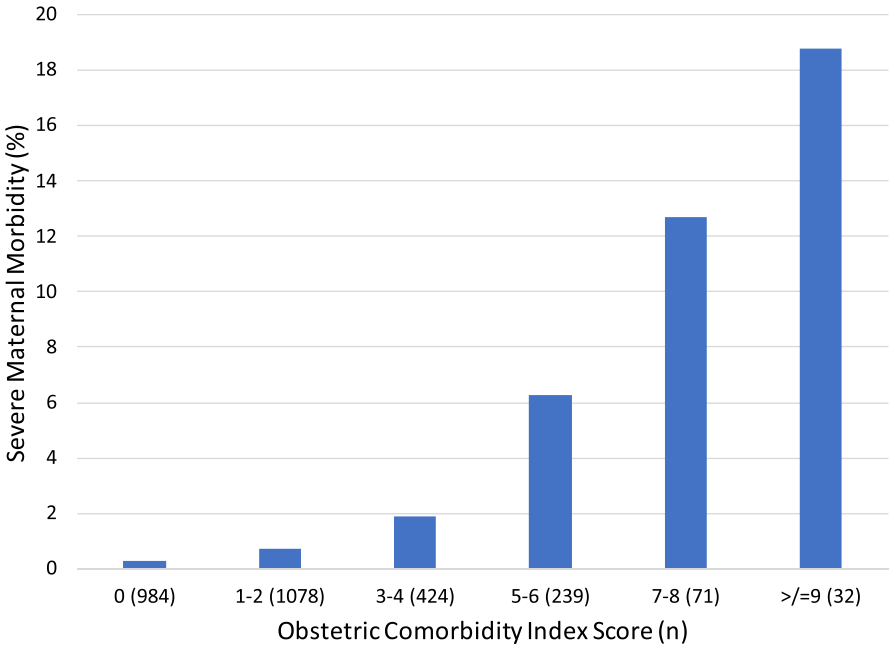
FIGURE 2
Obstetric comorbidity index associated with the development of severe maternal morbidity



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state that may preclude transfer. The integration of comorbidity and physiology-based risk prediction tools may offer improved sensitivity and specificity in detecting at-risk women and has already been identified as an important direction for future research.[20]

Critical Care Resources on Labor and Delivery

To encourage healthcare systems to develop and provide risk-appropriate maternal healthcare, the 2019 levels of maternal care obstetrical care consensus aims to stratify hospital systems by the availability of specific services with an emphasis on critical care resources.[6] The consensus provides evidence, suggesting that caring for the sickest women in higher acuity centers is associated with improved outcomes, highlighting the need to transfer patients with high-risk comorbidities to hospitals with the resources and personnel to address their anticipated needs.[21,22] The highest categories of care, levels III and IV, are reserved for health systems that provide obstetrical care to women at high risk of severe maternal morbidity or mortality as a part of a regionalized network of care.[6] A key distinguishing feature between a level III center and a level IV center is the availability of an intensivist model that incorporates comanagement with the MFM team. Therefore, a collaborative multidisciplinary approach to care of obstetrical patients who are critically ill is a key tenet in the provision of risk-appropriate care.

In addition to encouraging risk-appropriate care, the levels of maternal care guidelines emphasize encouraging the equitable distribution of resources across geographic regions.[23] Therefore, critical care resource management, an issue central in the regionalization of maternal critical care, becomes essential in the setting of potential resource shortages. Resource management planning has represented a vital component of healthcare during the coronavirus disease 2019 (COVID-19) crisis, as many hospitals have experienced a shortage of ventilators, medications, and blood products during this crisis.[24,25] For some hospitals with limited exposure to obstetrical patients who are critically ill, the need for clinicians with experience in managing obstetrical patients who are critically ill became a more pressing need. However, this need is not unique to the pandemic. A critical care physician, immediately available on labor and delivery for high-risk obstetrical patients, can provide insight into critical care diagnoses and comanagement of end-organ dysfunction while imparting knowledge on the obstetrical team.

Increasing the reliance of the US healthcare system on virtual electronic health record monitoring, such as telemedicine, calls into question the utility of this technology as a pathway for the delivery of critical care in obstetrics. The creation of innovative surveillance programs, such as the consultation, surveillance, monitoring, and intensive care (COSMIC) program, combines vital signs screening assessments with real-time "oversight" from critical care specialists by means of telemedicine. This intersectionality of critical care and obstetrics provides exciting new pathways for the delivery of timely, targeted multidisciplinary care.[26]

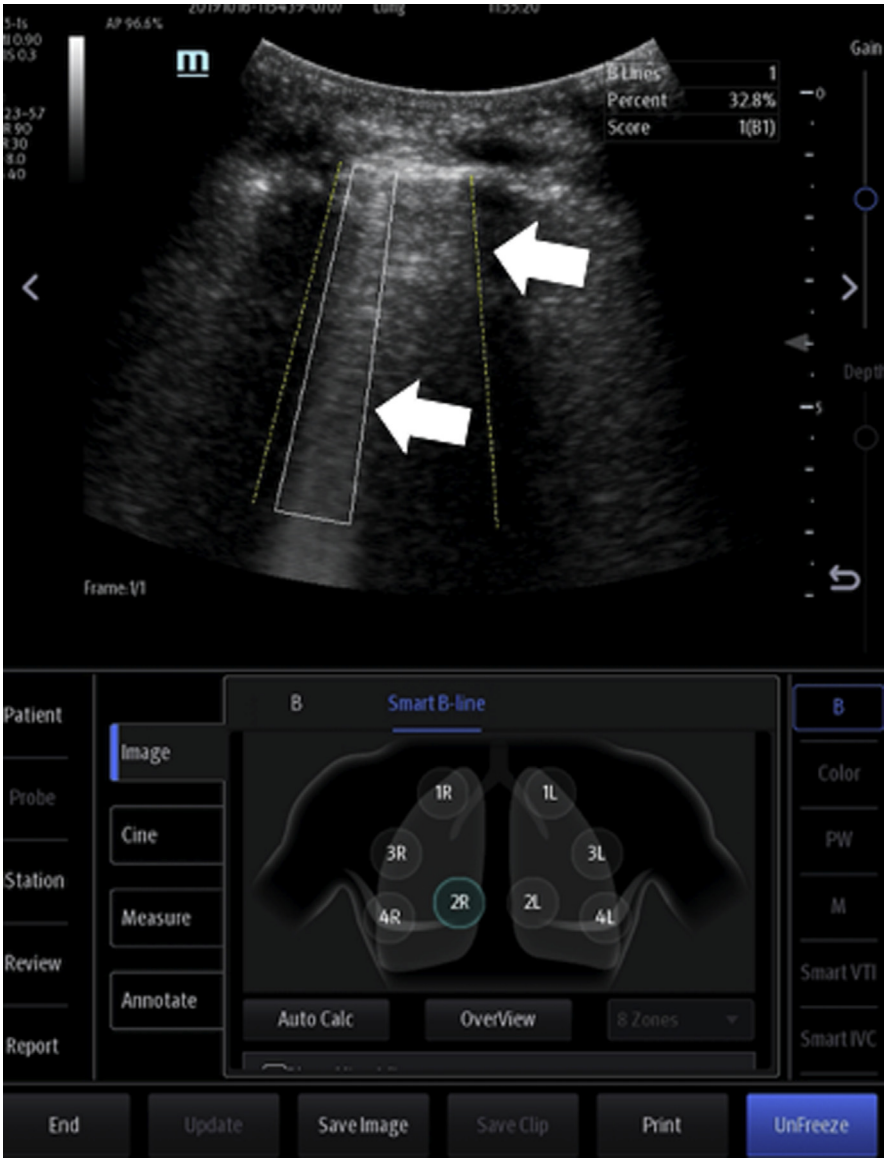
In addition to telemedicine-inspired critical care pathways, alternative obstetrical critical care delivery models have also previously been proposed. The "virtual ICU" is a model for critical care delivery in which a multidisciplinary team provides structured obstetrical ICU level care in nontraditional settings, such as cardiac care units and neuro-ICUs.[27,28] The "virtual ICU" model weaves together multispecialty physicians and ancillary staff based on the specific, critical needs of the patient.[28] The goal is to tailor specific care to a pregnant patient who is critically ill by emphasizing early identification of complications, detailed antepartum planning, and efficient resource allocation.

Alternative delivery models of obstetrical critical care (COSMIC, virtual ICU) can be combined with already existing critical care tools, such as point-of-care ultrasound. This can provide rapid, actionable information for obstetrical providers in fluid management, especially considering recent

findings showing that 67% of patients with late-onset preeclampsia (with severe features) have evidence of pulmonary edema, diastolic or systolic dysfunction on transthoracic echocardiography.[32] Many of these findings, such as acute pulmonary edema, create reproducible patterns (B-lines) and are easily identified on ultrasound (Figure 3).[29] Point-of-care ultrasonography has shown consistent reliability across a variety of clinical settings and has also been used during the current COVID-19 crisis to rapidly and reliably diagnose pulmonary edema and other pathologic states, representing a potential avenue for use in the triaging of obstetrical patient's with COVID-19.[33]

Point-of-care ultrasonography is a valuable tool for the rapid identification of common obstetrical emergencies, such as intraabdominal hemorrhage.[34] The use of the Focused Assessment with Sonography for Trauma protocol has been validated in emergency and trauma settings.[30,31] The presence of fluid within the abdominal compartment using a readily available ultrasound saves time that might be lost awaiting computed tomography or other imaging results. Intensivists can use bedside ultrasonography to assess intravascular hemodynamic status quickly with validated results.[31] Furthermore, bedside ultrasonography can assess rapid fluid shifts during complex surgical procedures, such as during a complex cesarean hysterectomy for placenta accreta spectrum. Massive hemorrhage may also lead to underresuscitation. Conversely, massive transfusion puts patients at higher risk of pulmonary edema or other complications, such as transfusion-associated circulatory overload or transfusion-related acute lung injury, emphasizing the need for targeted interventions and timely identification of end-organ dysfunction using bedside ultrasonography.[35]

FIGURE 3
Ultrasonographic findings of pulmonary edema - Smart B-Lines automated B Line quantification on the TE7 ultrasound system



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Critical Care Skills in Obstetrics

Looking ahead, the incorporation of critical care education; critical care skills, such as point-of-care ultrasonography; on-site critical care consultation; and creative resource management will be necessary to adapt to an increasingly complex parturient population. The incorporation of "specialty" skills into the educational curriculum in the obstetrics and gynecology residency programs has been advocated for in the past.[36] The current crisis in maternal morbidity and mortality represents an opportunity for a foundational change in our educational approach to high-risk obstetrical patients. In the alignment with the expert consensus, this can allow for an "early tracking" of subspecialty care to adapt to an increasingly complex parturient population.[36] Critical care in obstetrics represents an opportunity for "early tracking" of critical care interests, in accordance with the previously stated goals by the American Board of Obstetrics and Gynecology.[36] Skills, such as point-of-care ultrasonography for the rapid diagnosis of acute conditions (eg, cardiomyopathy and pulmonary

edema), are now integral components of the educational curricula in internal medicine, anesthesiology, and surgery residency programs.[37–39] Many specialty societies recognize the need for such training. The American College of Surgeons offers a comprehensive ultrasonography course for surgical residents.[39] The Society of Cardiovascular Anesthesiology recently published a "Call to Action" paper discussing the need for essential ultrasonography skills among anesthesiology residents.[38] Leading obstetrical societies currently offer postgraduate point-of-care ultrasonography education to providers. The SMFM, together with Banner University Medical Center, has incorporated an introduction to critical care ultrasonography, among other critical care skills (airway management, intraosseous line placement) in their annual Critical Care in Obstetrics course (Video 2).[40] Point-of-care ultrasound represents a familiar tool for obstetrical providers with novel and potentially powerful applications when used to evaluate maternal anatomy associated with commonly diagnosed disorders of pregnancy (preeclampsia). We recognized the need to develop standardized, validated educational pathways for obstetrics and gynecology and MFM trainees and for practicing obstetricians in point-of-care ultrasonography.

Promoting a Maternal Critical Care Model

A "cultural" evolution that changes how quickly and accurately we respond to and treat critical illness in pregnancy is required to meet the demands of the contemporary obstetrical environment. This evolution will require a multifaceted approach and a shift in the way we conceptualize obstetrical critical care and education. In line with the levels of maternal care consensus mandates for coordinated efforts between ICUs and obstetrical units, hospitals can use multidisciplinary critical care teams for the highest risk obstetrical patients, as described by the "virtual ICU" model, to meet the demands of the consensus.[27,28]

With alarming rates of maternal morbidity and mortality in the United States, we have reached a crossroads in how we deliver critical care. We must employ evidence-based screening tools for obstetrical comorbidities, encourage the widespread use of on-site critical care resources, integrate a multidisciplinary team-based approach, and promote early-career critical care education to optimize care for an increasingly complex parturient population.

Major Points

- Incorporate validated, evidence-based comorbidity screening tools, such as the OB-CMI in the antenatal and peripartum setting to promote early detection of patients at risk of clinical decompensation.
- Refer obstetrical patients with a high comorbidity burden to the appropriate level of care hospitals, as designated by the levels of maternal care consensus definitions.
- Rapidly identify critical illness using a multidisciplinary team and on-site (labor and delivery) critical care consultations for patients at risk of clinical decompensation.
- Integrate standardized educational pathways for basic critical care concepts and skills, including point-of-care ultrasonography, providing all obstetricians with the skillset to diagnose and stabilize a patient who is critically ill for transfer.
- Promote innovative approaches to provide critical care oversight and provide support to hospitals without on-site critical care services and to areas without level III or IV facilities. ■

REFERENCES

1. Petersen EE, Davis NL, Goodman D, et al. Vital signs: pregnancy-related deaths, United States, 2011-2015, and strategies for prevention, 13 states, 2013-2017. MMWR Morb Mortal Wkly Rep 2019;68:423–9.
2. Macdorman MF, Declercq E, Cabral H, Morton C. Recent increases in the U.S. maternal mortality rate: disentangling trends from measurement issues. Obstet Gynecol 2016;128:447–55.
3. Centers for Disease Control and Prevention. Severe maternal morbidity in the United States. 2020. Available at: https://www.cdc.gov/reproductivehealth/maternalinfanthealth/severematernalmorbidity.html. Accessed August 4, 2020.
4. The Faculty of Intensive Care Medicine. About intensive care. Available at: https://www.ficm.ac.uk/faculty-membership/about-intensive-care. Accessed August 4, 2020.
5. Martin JA, Hamilton BE, Sutton PD, et al. Births: final data for 2005. Natl Vital Stat Rep 2007;56:1–103.
6. American Association of Birth Centers, Association of Women's Health, Obstetric and Neonatal Nurses, American College of Obstetricians and Gynecologists, et al. Obstetric Care Consensus #9: levels of maternal care: (replaces obstetric Care Consensus number 2, February 2015). Am J Obstet Gynecol 2019;221:B19–30.
7. D'Alton ME, Bonanno CA, Berkowitz RL, et al. Putting the "M" back in maternal-fetal medicine. Am J Obstet Gynecol 2013;208:442–8.
8. D'Alton ME, Friedman AM, Bernstein PS, et al. Putting the "M" back in maternal-fetal medicine: a 5-year report card on a collaborative effort to address maternal morbidity and mortality in the United States. Am J Obstet Gynecol 2019;221:311–7.
9. Society for Maternal-Fetal Medicine (SMFM), Sciscione A, Berghella V, et al. Society for Maternal-Fetal Medicine (SMFM) Special Report: the maternal-fetal medicine subspecialists' role within a health care system. Am J Obstet Gynecol 2014;211:607–16.
10. D'Alton ME. Where is the "M" in maternal-fetal medicine? Obstet Gynecol 2010;116:1401–4.
11. Mhyre JM, D'Oria R, Hameed AB, et al. The maternal early warning criteria: a proposal from the national partnership for maternal safety. Obstet Gynecol 2014;124:782–6.
12. Friedman AM, Campbell ML, Kline CR, Wiesner S, D'Alton ME, Shields LE. Implementing obstetric early warning systems. AJP Rep 2018;8:e79–84.
13. Lappen JR, Keene M, Lore M, Grobman WA, Gossett DR. Existing models fail to predict sepsis in an obstetric population with intrauterine infection. Am J Obstet Gynecol 2010;203:573.e1–5.
14. Jain S, Guleria K, Suneja A, Vaid NB, Ahuja S. Use of the sequential organ failure assessment score for evaluating outcome among obstetric patients admitted to the intensive care unit. Int J Gynaecol Obstet 2016;132:332–6.
15. Singer M, Deutschman CS, Seymour CW, et al. The third international consensus definitions for sepsis and septic shock (Sepsis-3). JAMA 2016;315:801–10.
16. Easter SR, Bateman BT, Sweeney VH, et al. A comorbidity-based screening tool to predict severe maternal morbidity at the time of delivery. Am J Obstet Gynecol 2019;221:271.e1–10.
17. Bliddal M, Möller S, Vinter CA, Rubin KH, Gagne JJ, Pottegård A. Validation of a comorbidity index for use in obstetric patients: a nationwide cohort study. Acta Obstet Gynecol Scand 2020;99:399–405.

18. Vanderlaan J, Dunlop A, Rochat R, Williams B, Shapiro SE. Methodology for sampling women at high maternal risk in administrative data. BMC Pregnancy Childbirth 2019;19:364.

19. Leonard SA, Kennedy CJ, Carmichael SL, Lyell DJ, Main EK. An expanded obstetric comorbidity scoring system for predicting severe maternal morbidity. Obstet Gynecol 2020;136:440–9.

20. Bateman BT, Robinson JN. Getting risk prediction right. Obstet Gynecol 2020;136:437–9.

21. Clapp MA, James KE, Kaimal AJ. The effect of hospital acuity on severe maternal morbidity in high-risk patients. Am J Obstet Gynecol 2018;219:111.e1–7.

22. Shamshirsaz AA, Fox KA, Salmanian B, et al. Maternal morbidity in patients with morbidly adherent placenta treated with and without a standardized multidisciplinary approach. Am J Obstet Gynecol 2015;212:218.e1–9.

23. American College of Obstetricians and Gynecologists and Society for Maternal–Fetal Medicine, Menard MK, Kilpatrick S, et al. Levels of maternal care. Am J Obstet Gynecol 2015;212:259–71.

24. Ranney ML, Griffeth V, Jha AK. Critical supply shortages - the need for ventilators and personal protective equipment during the Covid-19 pandemic. N Engl J Med 2020;382:e41.

25. US Food and Drug Administration. Coronavirus (COVID-19) update: FDA provides updated guidance to address the urgent need for blood during the pandemic. 2020. Available at: https://www.fda.gov/news-events/press-announcements/coronavirus-covid-19-update-fda-provides-updated-guidance-address-urgent-need-blood-during-pandemic. Accessed August 4, 2020.

26. Lockhart EM, Hincker A, Klumpner TT, et al. Consultation, surveillance, monitoring, and intensive care (COSMIC): a novel 4-tier program to identify and monitor high-risk obstetric patients from the clinic to critical care. Anesth Analg 2019;128:1354–60.

27. Leovic MP, Robbins HN, Foley MR, Starikov RS. The "virtual" obstetrical intensive care unit: providing critical care for contemporary obstetrics in nontraditional locations. Am J Obstet Gynecol 2016;215:736.e1–4.

28. Leovic MP, Robbins HN, Starikov RS, Foley MR. Multidisciplinary obstetric critical care delivery: the concept of the "virtual" intensive care unit. Semin Perinatol 2018;42:3–8.

29. Lichtenstein DA, Mezière GA. Relevance of lung ultrasound in the diagnosis of acute respiratory failure the BLUE protocol. Chest 2008;134:117–25.

30. American College of Cardiology. Point of care ultrasound: an overview. 2017. Available at: https://www.acc.org/latest-in-cardiology/articles/2017/10/31/09/57/point-of-care-ultrasound. Accessed August 4, 2020.

31. Wesson HKH, Khan S, Ferrada P. Ultrasound as a tool for fluid status assessment in the trauma and critically ill patient. Int J Surg 2016;33:190–5.

32. Ortner CM, Krishnamoorthy V, Neethling E, et al. Point-of-care ultrasound abnormalities in late-onset severe preeclampsia: prevalence and association with serum albumin and brain natriuretic peptide. Anesth Analg 2019;128:1208–16.

33. Lichter Y, Topilsky Y, Taieb P, et al. Lung ultrasound predicts clinical course and outcomes in COVID-19 patients. Intensive Care Med 2020;46:1873–83.

34. Sailaja KB, Mk R. Critically ill obstetric admissions to an intensive care unit: a prospective analysis from a tertiary care university hospital in South India. Indian J Crit Care Med 2019;23:78–82.

35. Haldar R, Samanta S. Post-partum sequential occurrence of two diverse transfusion reactions (transfusion associated circulatory overload and transfusion related acute lung injury). J Emerg Trauma Shock 2013;6:283–6.

36. Hammond CB. Future directions for academic obstetrics and gynecology–"… through a glass, darkly …". Am J Obstet Gynecol 1995;172:1073–9.

37. LoPresti CM, Schnobrich DJ, Dversdal RK, Schembri F. A road map for point-of-care ultrasound training in internal medicine residency. Ultrasound J 2019;11:10.

38. Mahmood F, Matyal R, Skubas N, et al. Perioperative ultrasound training in anesthesiology: a call to action. Anesth Analg 2016;122:1794–804.

39. American College of Surgeons. Ultrasound for residents: the complete course. 2020. Available at: https://www.facs.org/education/accreditation/verification/ultrasound/residents. Accessed August 4, 2020.

40. Society for Maternal Fetal Medicine, Banner University Medical Center. Critical care in OBSTETRICS: an innovative and integrated model for learning the essentials. 2019. Available at: https://s3.amazonaws.com/cdn.smfm.org/media/1807/Brochure-Banner(FINAL).pdf. Accessed August 5, 2020.