The purpose of this review is to highlight some of the most notable publications relevant to anesthesiologists who practice obstetric anesthesia that were published in the calendar year 2017. It was presented in the keynote lecture “What’s New in Obstetric Anesthesia” that was delivered at the annual meeting of the Society for Obstetric Anesthesia and Perinatology in May 2018. To identify relevant articles, this Ostheimer lecturer searched the tables of contents of each new issue of a broad selection of major journals for articles related to obstetric anesthesia, obstetrics, perinatology, and health services research. From the large number of articles identified, 150 were included in a syllabus, and 34 were presented in the lecture. A description of the process of article selection as well as the syllabus is provided in Supplemental Digital Content, Document, http://links.lww.com/AA/C800. Themes covered in this review include postdischarge opioid prescriptions, anesthesia for external cephalic version, labor analgesia, maternal morbidity, and global health. The review ends with a list of proposed action items based on the 2017 literature.

POSTDISCHARGE OPIOID PRESCRIPTIONS

There is an epidemic of prescription opioid abuse in the United States. Cesarean delivery is one of the most common surgical procedures with approximately 1.3 million surgeries performed annually. It is common practice to discharge women after cesarean delivery with an oral opioid prescription, and if the number of opioid tablets dispensed exceeds the amount used, a problem arises where left-over opioids could be diverted or abused. Bateman et al previously estimated that 1:300 opioid-naive women become persistent opioid users after cesarean delivery. A challenge facing clinicians in defining the optimal number of opioid tablets to be prescribed has been the lack of information on the patterns of opioid use and the limited data on the trajectory of pain resolution and functional recovery after cesarean delivery. A few studies that attempted to address this gap were published in 2017. Komatsu et al performed a prospective observational study involving 213 healthy nulliparous women who attempted vaginal delivery. Those women were contacted daily to assess pain, analgesic use, and functional recovery. Of the 134 women who completed the study, 99 delivered vaginally and 35 underwent a cesarean delivery. The primary outcome of the study was time to pain- and opioid-free functional recovery, which was significantly longer after cesarean delivery (median [range], 27 days [10–85 days]) compared with vaginal delivery (19 days [3–77 days]; P = .0003). Opioids were used for ≥1 day by 31% of patients after vaginal delivery and 91% of patients after cesarean delivery. The median (range) time to opioid cessation was 0 days (0–14 days) after vaginal delivery and 9 days (0–39 days) after cesarean delivery (P < .0001). While the study only included healthy nulliparous women and there was a high dropout rate especially after 7 days postpartum, it does reveal significant variability in recovery and analgesic needs which highlight the importance of focusing on the development of an individual approach to opioid prescription after discharge.

Two studies surveyed women about postdischarge opioid prescription and use. Bateman et al performed phone surveys 2 weeks after discharge of 720 women who had a cesarean delivery at 6 academic centers. Opioid prescriptions were filled by 85.4% of women. The median number of dispensed tablets was 40, while the median number of used tablets was 20; 95.3% of women had not disposed of their unused opioids at the time of the interview. There was an association between the number of opioids dispensed and consumed with greater opioid consumption in those receiving 31–40 or >40 tablets compared to those who were dispensed ≤30 tablets (incidence rate ratio, 1.35; 95% CI, 1.11–1.65; and incidence rate ratio, 2.01; 95% CI, 1.48–2.76, respectively). There was, however, no correlation of number of prescribed tablets with satisfaction, pain scores, or need for refills, but increased number of prescription tablets was...
associated with an increase in opioid-related side effects. Osmundson et al\(^5\) also performed a similar single institution phone or e-mail survey at day 1 and 2 weeks after cesarean delivery. The results were comparable to those reported by Bateman et al;\(^6\) 83% of women used opioids for a median of 8 days, and the median number of oxycodone tablets dispensed was 30. Seventy-five percent of women had unused opioid tablets, with a median number of 10, and 93% had not disposed of unused opioid tablets at the time of the interview. Women who were in the top quartile for opioid use were more likely to be smokers (relative risk, 3.51; 95% CI, 1.35–9.12), to have public insurance (relative risk, 1.45; 95% CI, 1.09–1.92), and had greater opioid consumption during hospital stay (relative risk, 2.59; 95% CI, 1.61–4.17) compared to those in the average quartile for opioid use. While those surveys might have some limitations in terms of recall bias or generalizability, they seem to be conveying a consistent message: clinicians are prescribing too many opioids, women are not disposing of them, and there are certain patient characteristics that might help determine those who need more opioids. Therefore, the one-size-fits-all approach, where all women are given the same number of opioid prescriptions, risks under- or overprescribing. Prabhhu et al\(^6\) investigated one approach to align the number of prescription opioids dispensed with the amount used. In this study, 50 women participated in a 10-minute shared decision-making session during which an obstetrician or anesthesiologist provided information on the anticipated pattern of pain in the first 2 weeks after cesarean delivery, expected outpatient opioid use based on in-hospital pain scores, risks and benefits of opioid analgesics, and education on how to refill and dispose of opioids. At the end of the session, women chose the number of 5-mg oxycodone tablets to be prescribed on discharge, ranging from 0 to 40; 40 being the standard number of tablets prescribed at their institution at that time. The primary outcome of the study, the median number of oxycodone tablets chosen, was 20, which is 50% of what was commonly prescribed at the time of the study. The median number of tablets used was 15; only 4 patients (8%) needed refills, 67% of patients had a plan to dispose of opioids, and 90% were satisfied or very satisfied with the intervention. The patients particularly appreciated the education about outpatient course and the information about risks and benefits of oxycodone. Generalizability might be an issue with this study because 72% of patients were privately insured, and one-third of eligible patients declined to participate. The study, however, highlights one approach to individualize opioid prescriptions that was associated with high patient satisfaction. Patient education was a key contributor to the success of this intervention. Obstetric anesthesiologists should partner with their obstetric colleagues to educate parturients about postpartum pain management and opioid use and to develop strategies to individualize postdischarge opioid prescriptions.

**NEURAXIAL ANALGESIA AND ANESTHESIA FOR EXTERNAL CEPHALIC VERSION**

Focused efforts are needed to reduce cesarean delivery rates. Therefore, in the absence of contraindications, the American College of Obstetricians and Gynecologists recommends offering external cephalic version to all near-term women with breech presentations.\(^7\) A meta-analysis reported that neuraxial techniques for external cephalic version increase the success rate by 44% and reduce the cesarean delivery rate by 17%, while also reducing pain scores during the procedure.\(^8\) Bupivacaine has been commonly used for spinal anesthesia, but the optimal dose of intrathecal bupivacaine for external cephalic version is not clear. A meta-analysis using indirect comparisons suggested that higher anesthetic doses rather than lower analgesic doses are needed to increase the success of external cephalic version, but no dose–response studies have been previously conducted.\(^9\)

To address this gap, Chalifoux et al\(^10\) performed a randomized controlled study that evaluated success of external cephalic version (primary outcome) in women who were randomized to receive 1 of 4 doses of intrathecal isobaric bupivacaine (2.5, 5, 7.5, and 10 mg) in combination with fentanyl 15 µg as part of a combined spinal epidural technique. The overall success rate was 51.5% with no significant differences between the groups in success of external cephalic version or cesarean delivery rate. While women in the 7.5 and 10 mg groups were more comfortable compared to those in the 2.5 mg group, pain scores overall were low with no difference between the groups in patient satisfaction. Women receiving the higher doses had higher sensory levels, more hypotension, and their discharge from hospital was delayed compared with the lower doses with a median delay of 77 and 106 minutes for the 7.5- and 10-mg doses, respectively, compared with the 2.5-mg dose, and of 56 and 85 minutes, respectively, compared with the 5-mg dose. While this study did not include a control group not receiving spinal anesthesia, an older study from the same institution that included a group not receiving neuraxial anesthesia reported a success rate of 31%,\(^11\) which is lower than that the success rate of 50%–52% in this current study, therefore indirectly confirming the role of neuraxial anesthesia in facilitating external cephalic version. The results of this study have practical applications; if it is planned to discharge the patient after the external cephalic version, then the use of lower doses is recommended given the delayed discharge seen with higher doses. However, if the plan is to deliver the patient after the procedure, then the use of higher doses should be considered, and because there is a small chance of needing an emergency cesarean delivery, it is prudent to use a combined spinal epidural technique.

**LABOR ANALGESIA**

**Dural Puncture Epidural Technique**

The dural puncture epidural technique is similar to a needle-through-needle combined spinal epidural technique, except that after puncturing the dura with the spinal needle, no intrathecal medications are given, and all medications are then administered through the epidural catheter. Earlier studies suggested better sacral coverage and less asymmetric block with the dural puncture epidural technique performed using a 25- to 26-gauge pencil point needle\(^12\) as compared with the epidural technique; however, no benefit was reported when using a 27-gauge needle.\(^13\) Chau et al\(^14\) performed a randomized controlled trial where 120 women in active labor requesting labor analgesia were randomized...
to have their analgesia initiated with an epidural, combined spinal epidural, or dural puncture epidural technique and maintained with the same regimen using continuous epidural infusion with patient-controlled epidural analgesia. The primary outcome of time to pain score of ≤1 was shortest with the combined spinal epidural technique (median, 2 minutes) with no difference between the dural puncture epidural and epidural techniques (median, 11 and 18 minutes, respectively; hazard ratio, 0.36; 95% CI, 0.22–0.59; P < .001 for dural puncture epidural versus combined spinal epidural; and hazard ratio, 1.4; 95% CI, 0.83–2.4; P = .21 for dural puncture epidural versus epidural). A number of secondary outcomes were examined including less need for physician top-ups with the dural puncture epidural and combined spinal epidural techniques (10% with both techniques) compared with the epidural technique (52.5%; P < .001) and less asymmetric block with the dural puncture epidural technique (32.5%; P < .001) compared to the epidural technique (52.5%; relative risk, 0.19; 95% CI, 0.07–0.51; P < .001); and less pruritus (10% vs 67.5%; relative risk, 0.15; 95% CI, 0.06–0.38; P < .001), hypotension (12.5% vs 32.5%; relative risk, 0.38; 95% CI, 0.15–0.98; P = .032), tachysystole (10% vs 45%; relative risk, 0.22; 95% CI, 0.08–0.60; P < .001), and category II fetal heart rate tracing (12.5% vs 32.5%; relative risk, 0.38; 95% CI, 0.15–0.98; P = .032) with the dural puncture epidural compared with the combined spinal epidural technique. However, the authors did not adjust for the multiple secondary outcomes. Those promising results in favor of the dural puncture epidural technique (52.5%; P < .0001 for dural puncture epidural versus combined spinal epidural techniques) compared with the epidural technique (50% with both techniques; relative risk, 0.45; 95% CI, 0.23–0.86; P = .01) and less asymmetric block with the dural puncture epidural and combined spinal epidural techniques (10% with both techniques) compared with the epidural technique (22.5% versus 32.5%; 95% CI of difference, −6.8% to 12.8%; P = .52) were not significant differences between the groups in the rate of cesarean delivery (1% vs 1%; 95% CI of difference, −0.1% to 0.3%; P = .50), instrumental delivery (1% vs 2.5%; 95% CI of difference, −1.6% to 4.6%; P = .25), or episiotomy (32% vs 35%; 95% CI of difference, −6.8% to 12.8%; P = .52); however, women in the saline group were less satisfied with analgesia (median range [satisfaction scores, 9 [8–10] vs 10 [10–10]; P = .001). While this is a single-center study in China where practice might be different from US practice, it provides support for the lack of impact of contemporary low-dose epidural analgesia on the duration of the second stage of labor. It also supports data from a meta-analysis that suggested the practice of discontinuing epidural analgesia in the second stage of labor is not recommended because it does not impact labor outcomes or the risk of instrumental delivery and results in inadequate pain relief and increase in maternal pain scores.18

Epidural Fentanyl and Breastfeeding

Lipid-soluble opioids (eg, fentanyl and sufentanil) have a synergistic effect when added to local anesthetics for labor analgesia allowing lower doses of local anesthetics to be used thus reducing the risk of motor block and possibly impacting the risk of instrumental delivery while also improving the quality of the block. There are, however, limited and conflicting data about the impact of neuraxial analgesia on breastfeeding success; one study reported that women who received epidural fentanyl doses >150 µg were more likely to stop breastfeeding at 6 weeks compared to those who received lower doses of fentanyl or no fentanyl.20 In that study, the authors suggested that this might have been due to the highly lipophilic fentanyl crossing the placenta leading to neonatal depression and affecting neurobehavior scores. To further evaluate the impact of epidural fentanyl on breastfeeding, Lee et al21 randomized 305 parous women, who had previous breastfeeding success and had labor analgesia initiated with a combined spinal epidural technique, to have their analgesia maintained with continuous epidural infusion and patient-controlled epidural analgesia using bupivacaine 0.1% with no fentanyl, bupivacaine 0.08% with fentanyl 1 µg/mL, or bupivacaine 0.0625% with fentanyl 2 µg/mL. Breastfeeding rate at 6 weeks (primary outcome) was high with no significant differences between the groups (97% vs 98% vs 94%; P = .34). There were more women with motor block at the time of delivery in the group receiving no fentanyl compared to those receiving fentanyl 2 µg/mL (difference, 14%; 95% CI, 2%–26%; P < .001). It is important to note that only 18% of women in this study were exposed to cumulative fentanyl doses >150 µg, likely due to initiation of analgesia with a combined spinal epidural technique and the relatively short duration of labor in this group of parous women. Overall, however, the study supports the practice and benefits of incorporating fentanyl in low-dose local anesthetic solutions for labor analgesia.

MATERNAL MORBIDITY

Maternal Cardiac Disease

Cardiovascular Mortality. Cardiovascular disease is currently the leading cause of maternal mortality in the United States and United Kingdom22,23 with cardiovascular conditions, including cardiomyopathy, accounting for 26.5% of maternal deaths in the United States in 2011–2013.24 Briller et al25 performed a retrospective study, using data from the Illinois Department of Public Health maternal mortality review database, to assess the contribution of specific cardiovascular disease to maternal deaths in Illinois over a 10-year period (2002–2012). There were 636 deaths during pregnancy or within 1 year of pregnancy termination (371:100,000 live births) with 22.2% of deaths attributable to cardiovascular disease. Acquired heart disease accounted for 97.1% of cardiovascular mortality with cardiomyopathy being the most common etiology (27.9%) followed by

Neuraxial Analgesia and the Duration of the Second Stage of Labor

While meta-analysis of some older studies reported prolongation of the second stage of labor with neuraxial labor analgesia,16 there are limited data on the impact of low-dose epidural analgesia used in current practice on the duration of the second stage of labor. In a double-blind study, Shen et al17 randomized 400 healthy nulliparous women who were receiving low-dose epidural analgesia with ropivacaine 0.08% and sufentanil 0.4 µg/mL to have their analgesia continued with the same solution in the second stage of labor or switched to a saline solution. The primary outcome of the duration of the second stage of labor was not significantly different between the groups (mean difference, 101 seconds; 95% CI, −3.5 to 7 minutes; P = .52). There were also no significant differences between the groups in the rate of cesarean delivery (0% vs 1%; 95% CI of difference, −0.1% to 0.3%; P = .50), instrumental delivery (1% vs 2.5%; 95% CI of difference, −1.6% to 4.6%; P = .25), or episiotomy (32% vs 35%; 95% CI of difference, −6.8% to 12.8%; P = .52); however, women in the saline group were less satisfied with analgesia (median range [satisfaction scores, 9 [8–10] vs 10 [10–10]; P = .001). While this is a single-center study in China where practice might be different from US practice, it provides support for the lack of impact of contemporary low-dose epidural analgesia on the duration of the second stage of labor. It also supports data from a meta-analysis that suggested the practice of discontinuing epidural analgesia...
stroke (22.9%), hypertensive disorders (12.9%), arrhythmias (10.7%), coronary artery disease (9.3%), valvular heart disease (4.3%), and aortic dissection (2.9%). Women with cardiovascular mortality were likely to be older and to die postpartum with 50.5% of deaths occurring in the first 6 weeks postpartum and 13.2% occurring antepartum. Deaths were deemed preventable in 28.1% of cases with patient factors (obesity, noncompliance, and smoking) and health care provider factors (incomplete or delayed diagnosis/treatment and failure of referral to higher levels of care) identified. This underscores the importance of referring women with cardiovascular disease to centers that have the required multidisciplinary expertise to care for them and of proper planning for postpartum care of those women to optimize their outcomes.

**Peripartum Cardiomyopathy.** As highlighted earlier, peripartum cardiomyopathy is one of the leading causes of maternal morbidity and mortality. Recommended treatment is currently similar to other forms of heart failure and includes decongestive therapy with vasodilators (if blood pressure allows) and diuretics, neurohumoral inhibition with β-blockers, angiotensin-converting enzyme inhibitors and mineralocorticoid receptor antagonists, anticoagulation, and noninvasive ventilation in patients with pulmonary congestion. High levels of prolactin and the production of an antiangiogenic cleared prolactin fragment have recently been recognized as important contributors to the pathophysiology of peripartum cardiomyopathy. Pilot data suggest that the dopaminergic agonist bromocriptine, which has been used to treat hyperprolactinemia and stop lactation in postpartum women, may improve left ventricular recovery in women with peripartum cardiomyopathy. In a multicenter prospective randomized trial, Hilfiker-Kleiner et al compared 2 regimens of bromocriptine treatment in addition to standard heart failure therapy in women with peripartum cardiomyopathy and an ejection fraction of <35%: 2.5-mg bromocriptine for 1 week or 5-mg bromocriptine for 2 weeks followed by 2.5 mg for 6 weeks. There was no difference between the groups in the primary outcome of left ventricular ejection fraction change from baseline to 6 months (21% vs 24%; 95% CI of difference, −3.2% to 8.3%; P = .38) or in full recovery of left ventricular function (52% vs 68%; odds ratio, 0.5; 95% CI, 0.17–1.49; P = .38) or in full recovery of left ventricular function (52% vs 68%; odds ratio, 0.5; 95% CI, 0.17–1.49; P = .38). There were no maternal deaths and no patients required heart transplantation or left ventricular assist device. While the study did not include a control group, bromocriptine was associated with a much higher rate of full left ventricular recovery and lower morbidity and mortality compared with other peripartum cardiomyopathy cohorts not treated with bromocriptine. An editorial accompanying the study suggested that recommendations for the treatment of peripartum cardiomyopathy should be updated to include bromocriptine.

**Mechanical Heart Valves.** Women with prosthetic mechanical heart valves represent another challenging group of parturients. The optimal anticoagulation regimen in those parturients is not clear because there are competing fetal and maternal interests. A meta-analysis of 10 studies reported that vitamin K antagonists were associated with the lowest risk of maternal mortality compared to sequential treatment (heparin in first trimester followed by vitamin K antagonists) and low molecular weight heparin (0.9% vs 2% vs 2.9%) but are teratogenic and associated with fetal complications (eg, embryoathy [nasal hypoplasia, stippled epiphyses, or both] and fetopathy [central nervous system or ocular abnormalities] [2% vs 1.4% vs 0%]) and less live births (64.5% vs 79.9% vs 92%) with doses >5 mg/d being associated with less live births (43.9% vs 83.6%) and more fetal anomalies (12.4% vs 2.3%) than lower doses. Low molecular weight heparin, while safe for the fetus, was associated with a higher risk of thromboembolic complications compared to vitamin K antagonists or sequential treatment (8.7% vs 2.7% vs 5.8%), and optimal dosing during pregnancy is unclear. Vause et al performed a prospective, population-based study using the UK Obstetric Surveillance System data to identify women with mechanical prosthetic heart valves in pregnancy from 2013 to 2015. Data were obtained for 58 women (3.7:100,000 maternities). Various anticoagulation regimens were used with low molecular weight heparin throughout pregnancy being the most commonly used regimen in 71% of cases. Only 16 women (28%) had a good maternal and fetal outcome. There were 5 maternal deaths (9%), and a further 24 (41%) suffered serious morbidity mostly related to under- or overanticoagulation. There was a poor fetal outcome from 26 (47%) pregnancies. The study highlighted several issues in the care of those women including inconsistent and inadequate anticoagulation management in terms of dosing and monitoring and the fact that 19% of women were not referred to a specialist center. An excellent review by Bhagra et al provided recommendations for the management of parturients with mechanical valves. Those women should be counseled about the maternal and perinatal risks of pregnancy as well as risks and benefits of different anticoagulation regimens to make an informed choice. The authors recommended vitamin K antagonists for women in second and third trimester in view of the lower maternal risk of thromboembolic complications. For women using ≤5 mg/d, the review suggested consideration for using vitamin K antagonists or switching from 26 (47%) pregnancies. The review also highlighted the importance of a multidisciplinary team approach in specialist centers with strict compliance with the chosen anticoagulation regimen.

**Hemorrhage**

**Tranexamic Acid.** Hemorrhage is one of the leading causes of maternal morbidity and mortality worldwide. Tranexamic acid is an antifibrinolytic agent that was shown to reduce surgical blood loss as well as death in adults with acute traumatic bleeding, where when given within 3 hours of injury, the Clinical Randomisation of an Antifibrinolytic in Significant Haemorrhage 2 (CRASH-2) trial reported a 30% reduction in death due to bleeding. In 2012, the World Health Organization recommended that tranexamic acid should be used for the treatment of
postpartum hemorrhage when first-line uterotonics fail or if hemorrhage was thought to be due to trauma, but the evidence for this recommendation was extrapolated mainly from trials in surgery and trauma. The World Maternal Antifibrinolytic trial enrolled 20,021 women ≥16 years of age with a clinical diagnosis of postpartum hemorrhage after vaginal or cesarean delivery from 193 hospitals in 21 countries, which were mostly low- to middle-income countries. Patients were randomly assigned to 1 g IV tranexamic acid or placebo in addition to usual care. If bleeding continued after 30 minutes or stopped and restarted within 24 hours of the first dose, a second dose of 1 g of tranexamic acid or placebo could be given. Death due to bleeding was significantly reduced with tranexamic acid (1.5% vs 1.9%; relative risk, 0.81; 95% CI, 0.65–1.00; \( P = .045 \)). Similar to the results of CRASH-2 trial, death due to bleeding was reduced by 31% when tranexamic acid was given within 3 hours of delivery (1.2% vs 1.7%; relative risk, 0.69; 95% CI, 0.52–0.91; \( P = .008 \)), but there was no benefit if given beyond 3 hours (2.6% vs 2.5%; relative risk, 1.07; 95% CI, 0.76–1.51; \( P = .70 \)). Laparotomy due to bleeding was also reduced with tranexamic acid (0.8% vs 1.3%; relative risk, 0.64; 95% CI, 0.46–0.85; \( P = .002 \)). There was no difference in adverse events between the groups and no increase in thromboembolic complications with tranexamic acid (0.3% in both groups). However, concerns have been expressed regarding the wide CIs that have actually included the null value of 1 suggesting that benefits might be marginal. Furthermore, it is not clear how generalizable those findings are to practice in high-resource countries; the 1.9% risk of death in the control group in this trial is 20–30 times higher than that in high-resource countries. The number needed to treat in the World Maternal Antifibrinolytic trial was 272, but it was estimated to be 35,587 in Australia assuming a postpartum hemorrhage incidence of 5% and similar relative risk reduction as found in the World Maternal Antifibrinolytic trial. Although there is uncertainty about the generalizability of the World Maternal Antifibrinolytic trial to practice in the United States, given the reported mortality reduction, the American College of Obstetricians and Gynecologists has recommended that tranexamic acid should be considered as an adjunct in the setting of postpartum hemorrhage when initial medical therapy fails. It is also currently unknown whether there is any benefit to prophylactic treatment with tranexamic acid, but a large clinical trial is currently underway by the Maternal-Fetal Medicine Units Network to answer this question (https://clinicaltrials.gov/ct2/show/NCT03364491).

**Fibrinogen Replacement.** Fibrinogen levels are higher during pregnancy compared to the nonpregnant state, and low fibrinogen levels are associated with progression to massive postpartum hemorrhage; however, the level of fibrinogen that should be targeted during treatment of postpartum hemorrhage is not clear. The Obstetrics Bleeding Study 2 (OBS2) study was a randomized controlled trial in which 663 women with postpartum hemorrhage of 1000–1500 mL were enrolled and managed using rotational thromboelastometry. If Fibtem A5 (Tem International, Munich, Germany) was ≤15 mm (equivalent to fibrinogen ≃300 mg/dL), patients were randomized to receive fibrinogen concentrate or placebo with the dose calculated to increase Fibtem A5 to >22 mm (equivalent to fibrinogen ≃400 mg/dL). Fifty-five women were randomized (28 fibrinogen group, 27 placebo). There was no difference between groups in the primary outcome of number of allogeneic blood products transfused (adjusted incidence rate ratio, 0.72; 95% CI, 0.3–1.7; \( P = .45 \)). Subgroup analysis suggested that fibrinogen replacement was not required if Fibtem A5 >12 mm or fibrinogen >200 mg/dL, but an effect below these levels could not be excluded. The study, therefore, suggests that a 200 mg/dL threshold might be appropriate for fibrinogen replacement in the setting of postpartum hemorrhage. However, only 7 patients were randomized with a fibrinogen level <200 mg/dL; therefore, more data at those fibrinogen levels are needed.

**Safety Bundles.** The California Maternal Quality Care Collaborative developed the obstetric hemorrhage toolkit in 2010 which was then updated in 2015. The implementation of this toolkit was associated with improved outcomes and was subsequently a mainstay for the development of the National Partnership for Maternal Safety Consensus Bundle for Obstetric Hemorrhage. In January 2015, the California Maternal Quality Care Collaborative established the California Partnership for Maternal Safety collaborative where this bundle was implemented in a large number of collaborative hospitals of various sizes and affiliations with >250,000 births per year. In a quality improvement impact study, Main et al reported that hemorrhage-related severe maternal morbidity was reduced by 20.8% in 99 collaborative hospitals compared with only 1.2% reduction in 49 noncollaborative hospitals (\( P < .0001 \)) when comparing baseline preintervention (January 2014–December 2014) to postimplementation (October 2015–March 2016) data. Improvement was seen in all hospital types with greater reductions seen in those with previous collaborative experience compared to those with no previous experience (28.6% vs 15.4%). While the study relied on administrative data sets for outcomes and was not randomized, it highlights the feasibility of successful implementation of the bundle in a large number of hospitals of different sizes and affiliations that were associated with improved outcomes in all hospital types.

**Preeclampsia**

**Hospital Delivery Volume and Complications Associated With Preeclampsia.** Preeclampsia is associated with significant maternal and neonatal morbidity and mortality. Ananth et al used the Premier database (2006–2012) to examine the impact of hospital delivery volume on rates of serious maternal complications in relation to severe preeclampsia in 439 hospitals in the United States. Hospital delivery volume was categorized as 25–500, 501–1000, 1001–2000, and >2000 deliveries per year. Severe preeclampsia was associated with increased rate of serious maternal complications compared with normotensive women (relative risk, 8.7; 95% CI, 7.6–10.1). Rate of severe preeclampsia increased from 0.8% in low delivery volume hospitals to 1.3% in high volume hospitals with >2000 deliveries per year. Mortality rates in relation to severe preeclampsia were lower in those high delivery volume hospitals compared to those with a low annual delivery volume of <2000. While there was no
variation in the risk of serious maternal complications by overall hospital volume, the risk progressively declined as the hospital-specific severe preeclampsia rate increased. This suggests that increased exposure to those critically ill pregnant women likely resulted in increased expertise and care at those centers with higher rates of severe preeclampsia resulting in better outcomes. This supports the concept of regionalization of care where high-risk women are cared for in institutions with adequate resources and expertise as suggested by the maternal levels of care.45

**Obstructive Sleep Apnea and the Risk of Preeclampsia.**
Women with obstructive sleep apnea might be at increased risk for hypertensive disorders of pregnancy and gestational diabetes mellitus, but studies have been conflicting, and some relied on self-reported symptoms rather than a sleep study or inadequately controlled for important confounders such as body mass index. Confirming whether this association exists is clinically relevant because hypertensive disorders of pregnancy and gestational diabetes mellitus are associated with maternal and perinatal morbidity, and obstructive sleep apnea could be a modifiable risk factor. To address this gap, Facco et al46 performed a large multicenter prospective cohort study that enrolled 3705nulliparous women at an early gestational age of 6–14 weeks. Those women underwent a home sleep study at early and midgestation. The prevalence of obstructive sleep apnea was 3.6% in early pregnancy and increased to 8.3% in mid pregnancy. The majority of cases identified were mild. There was still, however, an independent association between obstructive sleep apnea and preeclampsia (adjusted odds ratio, 1.94; 95% CI, 1.07–3.51 for early pregnancy; and adjusted odds ratio, 1.95; 95% CI, 1.18–3.23 for mid-pregnancy), hypertensive disorders of pregnancy (adjusted odds ratio, 1.46; 95% CI, 0.91–2.32 for early pregnancy; and adjusted odds ratio, 1.73; 95% CI, 1.19–2.52 for mid pregnancy), and gestational diabetes mellitus (adjusted odds ratio, 3.47; 95% CI, 1.95–6.19 for early pregnancy; and adjusted odds ratio, 2.79; 95% CI, 1.63–4.77 for mid pregnancy) after adjustment for age, body mass index, chronic hypertension, and pregnancy-related weight gain. Because it is unknown if treatment of obstructive sleep apnea prevents those outcomes, further studies should investigate whether strategies to screen for and treat obstructive sleep apnea in pregnancy can reduce the risk and complications of hypertensive disorders of pregnancy and gestational diabetes mellitus.

**Consensus Bundle on Severe Hypertension During Pregnancy.** To help reducing complications associated with hypertensive disorders of pregnancy, a new safety bundle was developed by the National Partnership for Maternal Safety under the guidance of the Council on Patient Safety in Women’s Health Care.47 The bundle includes a set of evidence-based guidelines which can be readily adapted to local practice so that any hospital can optimally manage parturients with hypertensive disorders of pregnancy. Similar to previous bundles, it is organized into 4 action domains: readiness, recognition and prevention, response, and reporting and systems learning. The readiness domain focuses on institutions ability to identify pregnant or postpartum patients at risk for morbidity and mortality from severe hypertension. The recognition component focuses on instituting protocols to measure blood pressure and urine protein in all pregnant and postpartum women; implementing systems for early identification of at-risk women; and educating parturients on the signs and symptoms of preeclampsia and hypertension. The response section promotes the development of protocols and checklists to ensure prompt and appropriate treatment of severe hypertension, preeclampsia with severe features, and eclampsia as well as for care escalation. Finally, the reporting and system learning bundle promotes implementing a culture of huddles for high-risk cases and postevent debriefs as well as a review of all severe hypertension, eclampsia, and intensive care admission cases to identify systems-based problems that can be addressed. Obstetric anesthesiologists with their significant expertise in hemodynamic monitoring and management should play a key role in facilitating the implementation of this bundle in collaboration with obstetric and nursing colleagues to improve patient safety. Specifically, anesthesiologists should be actively involved in blood pressure management and communicating with obstetricians regarding the need for invasive monitoring or IV infusions for blood pressure control, should initial therapy fail. Anesthesiologists should also be aware that the document does not recommend discontinuing magnesium sulfate infusion during cesarean deliveries, which is similar to the earlier recommendation in the American College of Obstetricians and Gynecologists’s 2013 Hypertension in Pregnancy document.48 In women with normal kidney function, the half-life of magnesium is 5 hours,49 and discontinuing magnesium during cesarean delivery will not significantly impact intraoperative levels but may result in subtherapeutic magnesium levels postpartum potentially placing those women at risk for seizures.

**GLOBAL HEALTH**
There are limited data examining the impact and cost-effectiveness of global health efforts in the obstetric patient population. Kybelle (an international, nongovernmental organization that promotes safe childbirth) established a 5-year collaboration (2007–2011) with Ghana Health service to improve obstetric care at a large, urban referral hospital in Accra. Quality improvement initiatives focused on systems, personnel, and communications were at the center of this program. Goodman et al50 performed a cost-effectiveness...
analysis to estimate the incremental cost–effectiveness ratio of this program, which represents the cost per disability-adjusted life-year averted by the intervention. During this collaboration, maternal mortality ratio decreased by 22% and stillbirth rate decreased by 52%. The incremental cost–effectiveness ratio was $158 (95% CI, $129–$195), which is 8 times less than the gross domestic product per capita in Ghana. While the generalizability of those calculations to other settings might be limited, this study provides evidence of the cost–effectiveness of this particular model that was associated with significant reductions in maternal mortality and stillbirth rate.

PROPOSED ACTION ITEMS

The reviewed literature provides some take-home messages for changes that could be incorporated in clinical practice. The list in the Table includes action items based on the 2017 literature. Many of those items would require multidisciplinary collaboration, but their successful implementation can contribute to improved safety and outcomes of the parturient. Finally, obstetric anesthesiologists can impact maternal and neonatal safety through involvement and support of global health efforts.

DISCLOSURES

Name: Asraf S, Habib, MBBS, MSc, MHSc, FRCA.

Conflicts of Interest: A. S. Habib is a senior editor for Anesthesia & Analgesia and has received research support from Pacira Pharmaceuticals, Inc, BioQ Pharma, Haylard Health, Trevena Inc, and Acacia Pharma. He also served on the advisory Board for Trevena Inc and Health Decisions.

This manuscript was handled by: Jill M. Mhyre, MD.

REFERENCES