Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Obstetric Emergency Update

Severe Acute Respiratory Syndrome COVID-19 and Hypertension

Lori J. Stack, MD[a], Allisyn Brady, PA-C[b,*]

KEYWORDS

• COVID-19 • Pregnancy • Assessment • Management • Preeclampsia
• Gestational hypertension • Severe hypertension of pregnancy • Eclampsia

KEY POINTS

- Pregnant women are at higher risk of COVID-19 infection, severe disease, morbidity, and mortality than their nonpregnant counterparts; fetal risks include preterm delivery, cesarean delivery, and stillbirth.
- A high index of suspicion is essential because symptoms of COVID-19 can be mistaken for or may mimic physiologic conditions and complications of pregnancy.
- Assessment and management of COVID-19-positive pregnancies should follow the ACOG and Society for Maternal-Fetal Medicine guidelines.
- Hypertension in the pregnant or postpartum patient should be immediately recognized and addressed because Hypertension (systolic >140 mm Hg and/or diastolic >90 mm Hg) in the pregnant or postpartum patient it is a leading contributor to both maternal and perinatal morbidity and mortality.
- Hypertension in pregnancy and the postpartum period (up to 12 months after delivery) can be habringers of cardiovascular disease, stroke, renal failure, and eclamptic seizures.
- Although the postpartum period is typically considered to be from birth to up to 6 weeks afterward, hypertension and cardiovascular complications may arise as late as 12 months after delivery.

SEVERE ACUTE RESPIRATORY SYNDROME CORONAVIRUS 2 AND PREGNANCY

Introduction

Much of the study of severe acute respiratory syndrome coronavirus 2 (SARS-COV-2) remains in its infancy, especially regarding pregnancy. Although the absolute risk of

[a] Center for Fetal Diagnosis and Treatment, Children's Hospital of Philadelphia, 3401 Civic Center Boulevard, Philadelphia, PA 19104, USA; [b] Cambridge Health Alliance, Department of Obstetrics and Gynecology, 1493 Cambridge Street, Cambridge, MA 02139, USA
* Corresponding author. Department of Obstetrics and Gynecology, Cambridge Health Alliance, 8 Camelia Avenue, Cambridge, MA 02139.
E-mail address: albrady@challiance.org

Physician Assist Clin 8 (2023) 109–122
https://doi.org/10.1016/j.cpha.2022.08.010
2405-7991/23/

severe morbidity and mortality remains low, data from the Centers for Disease Control and Prevention indicate that the risk for both intensive care unit (ICU) admission and invasive ventilation in pregnant symptomatic women is increased 3-fold compared with nonpregnant symptomatic women,[1] whereas the risk of extracorporeal membrane oxygenation is increased 2.4-fold and the risk of death from coronavirus disease 2019 (COVID-19) is increased by 70%. Women with comorbidities, those older than 35 years, and Latina and black women are all at increased risk for adverse maternal outcomes.[2] Severe-critical disease in pregnancy is associated with worse outcomes, and the Delta variant brought additive risk for severe-critical disease and death.[2,3]

The care of all COVID-19-positive pregnant patients requires a high index of suspicion and meticulous follow-up planning. Management of severe-critical patients requires complex care by a team including obstetrics, maternal-fetal medicine, neonatology, critical care, infectious disease, and obstetric anesthesiology.[3]

Immunology and Physiology of Pregnancy

Immunologic changes that occur routinely in pregnancy may lead to worse outcomes in COVID-19-positive women. Researchers at Johns Hopkins University noted a reduced antiviral antibody response in COVID-19-positive pregnancies.[4] In addition, the immune response in pregnancy naturally heightens cellular/innate immunity, which functions to prevent the fetus from being seen as "foreign." However, the compensatory or relative decrease in adaptive/humoral immunity leaves the mother more susceptible to infection. These changes may predispose pregnant women to increased severity with COVID-19 infection.[5]

Many of the normal physiologic changes of pregnancy leave expectant mothers with limited reserve as well as symptoms resembling those of COVID-19. Again, it is essential to consider many of these symptoms as ramifications of COVID-19 until proven otherwise. That is to say, the symptoms should not be considered as those of normal pregnancy without seeing and evaluating the patient. **Table 1** delineates important physiologic changes of pregnancy that place expectant mothers at increased risk when infected with COVID-19.[6]

COVID-19-Related Complications in Pregnancy

COVID-19 brought significant additional risk of specific pregnancy complications including venous thromboembolism, hypertensive disorders of pregnancy, cesarean delivery, preterm birth, and stillbirth.

Venous thromboembolism includes cerebral venous sinus thrombosis, arterial thrombosis, cerebral vascular accident, pulmonary embolism, and deep vein thrombosis. A study by the National Institute of Child Health and Human Development Maternal Fetal Medicine Units Network reported thromboembolism rates in severe-critical, mild-moderate, and asymptomatic pregnant women with COVID-19 as 6%, 0.2%, and 0%, respectively.[7]

Hypertensive disorders, including hemolysis, elevated liver enzymes, low platelets (HELLP) syndrome, eclampsia, preeclampsia with or without severe features, gestational hypertension, and chronic hypertension with superimposed preeclampsia, were present in 40.4% of pregnancies with severe-critical disease versus 18.8% of pregnancies with asymptomatic COVID-19 positivity.[6] Although an elevated incidence in severe-critical disease may be anticipated, it is crucial to note that the risk of hypertensive disease is significantly elevated in asymptomatic, COVID-19-positive pregnancies. Many of the laboratory abnormalities seen with COVID-19 will be the same as those seen with hypertensive complications of pregnancy. It is essential to determine the cause of these laboratory abnormalities because treatment will differ

Table 1
Physiologic changes of pregnancy that place expectant mothers at increased risk during coronavirus disease infection

	Cardiovascular	*Effect*
Increased	Plasma volume by 40–50%, but erythrocyte volume by only 20% Heart rate by 15–20 bpm Clotting factors susceptible to thromboembolism Dextrorotation of the heart Estrogen effect on myocardial receptors	Dilutional anemia results in decreased oxygen-carrying capacity Increased CPR circulation demands Increased CPR circulation demands Increased ECG left axis deviation Supraventricular arrhythmias
Decreased	Supine blood pressure and venous return with aortocaval compression Arterial blood pressure by 10–15 mm Hg Systemic vascular resistance COP PCWP	Decreases cardiac output by 30% Susceptible to cardiovascular insult Sequesters blood during CPR Susceptible to third spacing Susceptible to pulmonary edema
	Respiratory	*Effect*
Increased	Respiratory rate (progesterone mediated) Oxygen consumption by 20% Tidal volume (progesterone mediated) Minute ventilation Laryngeal angle Pharyngeal edema Nasal edema	Decreased buffering capacity Rapid decrease of Pa_{O_2} in hypoxia Decreased buffering capacity Compensated respiratory alkalosis Failed intubation Failed intubation Difficult nasal intubation
Decreased	Functional residual capacity by 25% Arterial P_{CO_2} Serum bicarbonate	Decreases ventilatory capacity Decreases buffering capacity Compensated respiratory alkalosis
	Gastrointestinal	*Effect*
Increased	Intestinal compartmentalization	Susceptible to penetrating injury
Decreased	Peristalsis, gastric motility Gastroesophageal sphincter tone	Aspiration of gastric contents Aspiration of gastric contents
	Uteroplacental	*Effect*
Increased	Uteroplacental blood flow by 30% of cardiac output Aortocaval compression Elevation of diaphragm by 4–7 cm	Sequesters blood in CPR Decreases cardiac output by 30% Aspiration of gastric contents
Decreased	Autoregulation of blood pressure	Uterine perfusion decreases with drop in maternal blood pressure

Abbreviations: COP, colloid oncotic pressure; CPR, cardiopulmonary resuscitation; ECG, electrocardiography; PCWP, pulmonary capillary wedge pressure.

depending on the underlying etiology. The diagnosis and management of hypertension in pregnancy are robust topics deserving significant attention; therefore the subject is discussed in detail later in this article.

Cesarean birth occurred in 59.6% of severe-critical disease pregnancies compared with 11.9% of asymptomatic patients.[7] Preterm delivery has been documented in 16.4% to 41.8% of pregnancies with severe-critical disease, depending on the

reporting entity.[2,7] Some of the early data may have been skewed by iatrogenic causes versus spontaneous preterm labor. More than 1.25 million women have delivered since the onset of COVID-19 in the United States. A recent retrospective study revealed an increased risk of severe maternal morbidity and mortality from obstetric causes (i.e. ICU admission and blood transfusion of 4 or more liters) in Covid positive pregnancies.[8] Data collected between March 2020 and September 2021 show that the adjusted relative risk of stillbirth was 0.59 before COVID-19, whereas that risk increased to 1.47 in the period before the arrival of the Delta variant. Within the Delta-predominant period, relative risk further increased to 4.4 or 2.07% of COVID-19-positive pregnancies.[9]

Triage

American College of Obstetricians and Gynecologists/Society for Maternal-Fetal Medicine Outpatient Assessment and Management for Pregnant Women with Suspected or Confirmed COVID-19 provides the current guidelines for triage. This flowsheet should be followed for guidance with assessment, triage, intensified outpatient monitoring, transfer to obstetric unit or ICU, or transfer to outside facility (**Fig. 1**).

Patient Evaluation

The patient should be assessed in an isolation room, and the patient should wear a mask. Health care workers should maintain droplet and contact precautions using gowns, gloves, masks, face shields, and goggles. N-95 masks have been reserved for cesarean delivery, second stage of labor, operating room (O.R) management of postpartum hemorrhage, and intubation.[3]

Clinical risks and exposure history should be assessed. Pregnancy alone is a risk factor for poor outcomes. Importantly, outcomes worsen in those with hypertensive

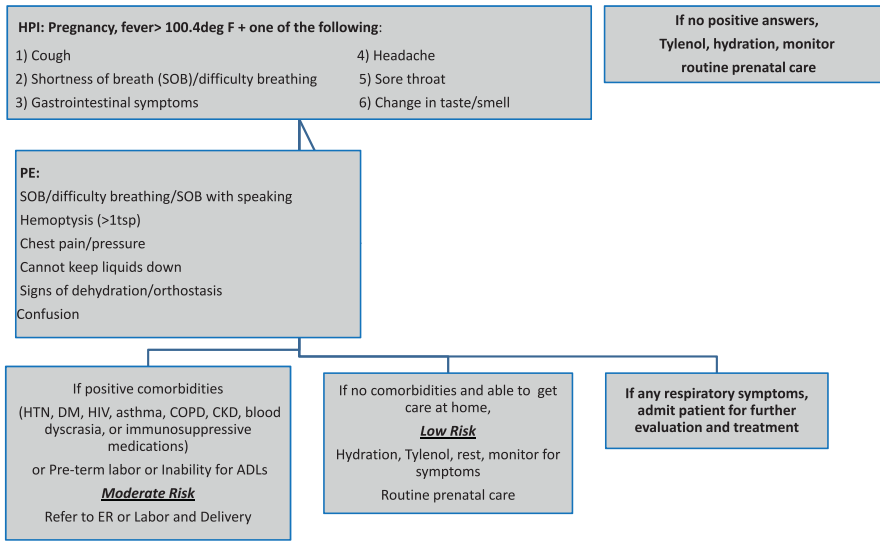

Fig. 1. HPI-history of present illness, SOB-shortness of breath, HTN-hypertension, DM-diabetes, COPD-chronic obstructive pulmonary disease, ADL-activities of daily living. *Adapted from* ACOG, Outpatient Assessment and Management for Pregnant Women With Suspected or Confirmed Novel Coronavirus (COVID-19).

disorders (preexisting or pregnancy-induced), chronic cardiopulmonary disease, diabetes (preexisting or gestational), obesity, renal disease, advanced maternal age, cancer, sickle cell disease, body mass index greater than 35 kg/m^2; immunocompromised state, and tobacco use.[10]

Physical Examination

Upon presentation, vital signs should be promptly obtained, including pulse oximetry reading. The normal oxygen saturation as measured by pulse oximetry (Spo_2) in a healthy pregnant woman is greater than or equal to 94% on room air. Also, the degree of hypoxia is often worse than what the clinical symptoms may suggest.[11] Fetal heart monitoring should be initiated if estimated gestational age is greater than or equal to 24 weeks. Supine positioning should be avoided to allow adequate blood flow to the fetus, especially after 24 weeks' gestation. A routine physical examination should be performed with detailed attention to lungs and heart. Laboratory parameters should be obtained including the following:

- Expedited COVID-19 polymerase chain reaction (PCR) test upon arrival (be aware that PCR can be false-negative; therefore, treat any symptomatic pregnant patient as if they are PCR positive)
- Complete blood cell count to evaluate for thrombocytopenia/hemolysis
- Comprehensive medical panel for abnormal liver function tests
- Arterial blood gases in patients with low SpO_2 (normal pregnancy values differ from those of nonpregnant patients. Normal first-trimester values: pH, 7.42–7.46; Pao_2, 105–106; $Paco_2$, 28–29; serum HCO_3, 18. Normal third-trimester values: pH, 7.43; Pao_2, 101–106; $Paco_2$, 26–30; serum HCO_3 17.[6]
- Urine protein or protein/creatinine ratio in patients with suspicion for gestational hypertension/preeclampsia
- Prothrombin time/partial thromboplastin time/international normalized ratio
- Ferritin levels in the presence of concern for cytokine storm[10]

D-dimer is naturally elevated in pregnancy and is thus not useful. Chest radiograph, if indicated, should be performed with an abdominal shield.

An obstetrician should be notified immediately of any PCR-positive patient or patient under investigation and any abnormality in vital signs, physical examination, or radiologic or laboratory studies.

Disease Severity and Disposition

Table 2 outlines disease severity, symptoms, findings, and appropriate disposition for COVID-19-positive pregnant women.

Management

Therapeutic options

In general, the National Institutes of Health COVID-19 treatment guideline therapies that would be given otherwise should not be withheld in the treatment of COVID-19-positive pregnant/lactating women. Still, it is prudent to consult an obstetrician before initiating medical therapy.

- Antenatal steroids for the sole purpose of fetal lung maturity: Use with caution and only before 34 weeks' gestation.[5]
- Anticoagulants in ICU setting. Consider in all hospitalized COVID-19-positive patients.[5]

Table 2
Severity scale for COVID-19 in pregnancy[9]

Severity at Presentation	Findings/Symptoms	Disposition
Asymptomatic	• Positive PCR test • No symptoms	• Home with precautions and daily self-monitoring, consider home pulse oximeter and/or BP cuff, prompt and regular follow-up with OB. • Be seen if increased SOB; tachypnea; unremitting temperature > 39°C; SpO_2 < 95%: nontolerance of medications or fluids; confusion/lethargy; pleuritic chest pain; cyanotic lips/fingertips; preterm contractions, vaginal bleeding or decreased fetal movement[9,10]
Mild disease	• Positive test • Flulike symptoms without dyspnea, shortness of breath, or abnormal chest imaging findings	• Home with precautions. • IV fluids if indicated • Consider home pulse oximeter and/or BP cuff • Admit if unable to tolerate p.o. • Prompt follow-up with OB
Moderate disease	• $SpO_2 \geq 95\%$ on room air • Evidence of lower respiratory tract disease with dyspnea, pneumonia on imaging, abnormal blood gases, or refractory temperature $\geq 39°C$	• Admit for maternal/fetal assessment and treatment on obstetric unit • Consider antibiotics for pneumonia, avoid quinolones if possible • Consider anticoagulation to prevent venous thromboembolism • Consider delivery for standard fetal indications
Severe disease	• $SpO_2 \leq 94\%$ on room air • Respiratory rate >30 bpm • Po_2/Fio_2 < 300 mm Hg[10] • >50% lung involvement on imaging	• Admit to ICU with consults • Include management listed under moderate disease
Critical disease	• Multiorgan failure or dysfunction • Shock	• Admit to ICU with multispecialty care team • Include management under moderate disease • Need for ventilation or high-flow nasal canula[9]

Abbreviations: BP, blood pressure; bpm, beats per minute; Fio_2, fraction of inspired oxygen; IV, intravenous; OB, obstetrician; p.o., per mouth; SOB, shortness of breath.

Adapted from Society For Maternal Fetal Medicine Management Considerations for Pregnant Patients With COVID-19 Developed with Guidance from Torre Halscott, MD, MS, Jason Vaught, MD, and Emily Miller, MD, MPH. 6-16-2020 (this is an update of the draft originally posted on 4-30-20).

- Antibiotics for the treatment of pneumonia are acceptable. Try to avoid quinolones.
- Acetaminophen: Consider as the first-line analgesia in milder cases.

- Nonsteroidal anti-inflammatory drugs: Consider over opioids for additional analgesia with obstetric consult. Opioids may pose higher clinical risk.[3]
- Avoid nitrous oxide in suspected or confirmed patients with COVID-19.
- Oxygen: Consider in the presence of maternal hypoxia. Consider for fetal indications.
- Magnesium sulfate: For seizure prophylaxis only in preeclampsia with severe features. Consider risk of eclampsia versus risk of respiratory depression.[3] Seizure prophylaxis dose is 4-6g load over 20-30 minutes followed by 2 g/h.
- Monoclonal antibodies: Accepted treatment of infected as well as inadequately vaccinated exposures
- Remdesivir: Accepted[2]
- Dexamethasone: If indicated, use fetal lung maturity dosing for the first 2 days of use if less than 34 weeks' gestation.[5]
- Baricitinib: If patient meets clinical US Food and Drug Administration (FDA) qualifications[2]
- Tocilizumab: If patient meets clinical FDA qualifications.[2]
- Paxlovid: If patient meets clinical FDA qualifications.[12]

Obstetric Management

Obstetric care/intervention for COVID-19-positive patients without severe-critical disease is similar to that for non-COVID-19 pregnancies. In less severe disease, induction of labor and cesarean delivery are reserved for normal obstetric indications. The risks of preterm delivery versus the risk of prolonged fetal hypoxemia should be considered in cases of prolonged maternal hypoxemia.[3]

Postpartum Management

Decision regarding keeping the infant with or separated from a COVID positive or COVID suspected mother should be made on a case by case basis by the mother and the care team.[8] The mother should be monitored/advised of potential COVID-19 complications up to 6 weeks postpartum.

HYPERTENSION IN PREGNANCY AND POSTPARTUM

Introduction

Hypertension in the pregnant or postpartum patient should be immediately recognized and addressed because it is a leading contributor to both maternal and perinatal morbidity and mortality.[13]

In pregnancy and the postpartum period, the diagnosis of hypertension is defined as systolic blood pressure equal to or greater than 140 mm Hg and/or a diastolic pressure equal to or greater than 90 mm Hg in at least two readings more than 4 hours apart.[13] Although most diagnoses of postpartum hypertension disorders are made within weeks of delivery, signs and symptoms can present as late as one year after birth.[14] For nonobstetric providers in the urgent care and emergency setting, it is crucial for enhanced awareness of hypertension in pregnancy and the potential for late presentation in the postpartum setting.

There are several classifications of hypertension in pregnancy (**Table 3**).[15] Each one of these classifications have their own indications for timing of delivery and also postpartum follow-up. Any patient with a diagnosis of hypertension in pregnancy, despite the classification, could develop preeclampsia and has the potential to develop severe range blood pressures. For the pregnant or postpartum patient, severe range blood pressures are defined as systolic blood pressure greater than or equal to 160 mm

Table 3
Classification of hypertensive disorders in pregnancy

Disorder	Characteristics
Chronic hypertension	Systolic blood pressure of 140 mm Hg or greater, diastolic blood pressure of 90 mm Hg or greater, or both known to predate consumption or detected before 20 wk of gestation
Gestational hypertension	New-onset hypertension that develops after 20 wk of gestation; in the absence of proteinuria[a]
Preeclampsia-eclampsia	Development of hypertension presenting after 20 wk of gestation with proteinuria[a]; in the absence of proteinuria, preeclampsia can manifest as new-onset hypertension with any of the following features: thrombocytopenia, renal insufficiency, impaired liver function, pulmonary edema, or cerebral or visual symptoms; eclampsia is the presence of new-onset grand mal seizures in a pregnant woman with preeclampsia
Chronic hypertension with superimposed preeclampsia	The onset of features diagnostic of preeclampsia in a woman with chronic hypertension beyond 20 wk of gestation

[a] Proteinuria is defined as 300 mg or more of protein in 24-h urine collection or the ratio of measured protein level to creatinine level in a single voided urine collection that equals or exceeds 3 (each measured as mg/dL), termed the protein-to-creatinine ratio.

Reprinted with permission from Schmitz PG, Nguyen T. Hypertension. Clin Update Womens Health Care 2016;XV(1):1–114. Available at: https://www.acog.org/clinical/journals-and-publications/clinical-updates.

Hg and/or diastolic blood pressure greater than or equal to 110 mm Hg and should be immediately identified to determine which treatment is warranted. This severe hypertension for pregnant and postpartum patients will give them the diagnosis of preeclampsia with severe features.[13] Consideration should be given to any severe range blood pressure because it could be a sign of preeclampsia and impending eclampsia and should be treated to prevent congestive heart failure, myocardial ischemia, renal injury or failure, and ischemic or hemorrhagic stroke.[13] The parameters of severe hypertension are much lower in pregnant and postpartum patients than the general population.

DISCUSSION

Gestational Hypertension

Gestational hypertension is defined as elevation in blood pressure after 20 weeks gestation, two elevations more than 4 hours apart, in a patient with no previous history of hypertension.[13] These patients do not have laboratory abnormalities or proteinuria; however, they are monitored closely and could develop preeclampsia. In fact, patients with gestational hypertension are managed similarly to patients with preeclampsia and may not be distinguishable. Patients with gestational hypertension should have a way of monitoring their blood pressure and be aware of any signs or symptoms of preeclampsia, because any patient with gestational hypertension could move on to develop preeclampsia and/or severe hypertension.

Chronic Hypertension

Patients who have been identified as having hypertension before 20 weeks' gestation are thought to have a history of chronic hypertension. Chronic hypertension can just

Box 1
Diagnostic criteria for preeclampsia

Blood pressure:
- Systolic blood pressure of 140 mm Hg or more or diastolic blood pressure of 90 mm Hg or more on two occasions at least 4 hours apart after 20 weeks' gestation in a woman with a previously normal blood pressure
- Systolic blood pressure of 160 mm Hg or more or diastolic blood pressure of 110 mm Hg or more. (Severe hypertension can be confirmed within a short interval (minutes) to facilitate timely antihypertensive therapy.)

and

Proteinuria
- 300 mg or more per 24-hour urine collection (or this amount extrapolated from a timed collection) or
- Protein/creatinine ratio of 0.3 mg/dL or more or
- Dipstick reading of 2+ (used only if other quantitative methods not available)

Or in the absence of proteinuria new-onset hypertension with the new onset of any of the following:
- Thrombocytopenia: Platelet count less than $100{,}000 \times 10^9$/L
- Renal insufficiency: Serum creatinine concentrations greater than 1.1 mg/dL or a doubling of the serum creatinine concentration in the absence of other renal disease
- Impaired liver function: Elevated blood concentrations of liver transaminases to twice normal concentration
- Pulmonary edema
- New-onset headache unresponsive to medication and not accounted for by alternative diagnoses or visual symptoms

Adapted from ACOG practice bulletin Number 222: Gestational hypertension and preeclampsia, June 2020.

be a history of hypertension before pregnancy, or if someone has not been diagnosed with a hypertensive disorder before pregnancy but present early in their pregnancy before 20 weeks' gestation with hypertension.[16] Patients with chronic hypertension can develop superimposed preeclampsia, so they should be monitored for signs and symptoms of preeclampsia. These patients should also have baseline laboratory test results including evaluation for proteinuria to see if there are any underlying signs of end-organ damage and can also be used if these laboratory values change during their pregnancy.

Preeclampsia/Eclampsia

Preeclampsia is defined as elevated blood pressure on two occasions (more than 4 hours apart) with proteinuria, usually after 20 weeks' gestation. Patients can become preeclamptic without having proteinuria based on certain laboratory values or symptoms alone (preeclampsia with and without severe features: **Boxes 1** and **2**).[13] There are two types of preeclampsia: preeclampsia without severe features and preeclampsia with severe features. A patient having "preeclampsia without severe features" needs to be monitored closely. Should a patient develop severe range blood pressure on two readings greater than 4 hours apart, the diagnosis becomes "preeclampsia with severe features," which requires treatment with magnesium sulfate for seizure and eclampsia prophylaxis. Two documented severe range blood pressures or persistent severe range blood pressure also requires immediate treatment with antihypertensive medication (**Tables 4** and **5**).[13] A repeat blood pressure should be obtained within 15 minutes of any severe range reading to ensure proper diagnosis and treatment.

Box 2
Preeclampsia with severe features

- Systolic blood pressure of 160 mm Hg or more, or diastolic blood pressure of 110 mm Hg or more on two occasions at least 4 hours apart (unless antihypertensive therapy is initiated before this time)
- Thrombocytopenia (platelet count <100,000 $\times$ 10^9/L)
- Impaired liver function that is not accounted for by alternative diagnoses and as indicated by abnormally elevated blood concentrations of liver enzymes (to more than twice the upper limit of normal concentrations), or by severe persistent right upper quadrant or epigastric pain unresponsive to medications
- Renal insufficiency (serum creatinine concentration more than 1.1 mg/dL or a doubling of the serum creatinine concentration in the absence of other renal disease)
- Pulmonary edema
- New-onset headache unresponsive to medication and not accounted for by alternative diagnoses
- Visual disturbances

Adapted from ACOG practice bulletin Number 222: Gestational hypertension and preeclampsia, June 2020.

Preeclampsia with severe features can also be defined with certain laboratory thresholds and would require magnesium sulfate treatment (see **Box 2**).[13] Preeclampsia can happen not only during pregnancy but also in the postpartum period; this can be confusing because the cure for preeclampsia is thought to be delivery of the baby. However, someone could present with initial signs for a diagnosis of preeclampsia with or without severe features once the baby is delivered up until 6 weeks and

Table 4
Antihypertensive agents used for urgent blood pressure control in pregnancy

Drug	Dose	Comments	Onset of Action
Labetalol	10–20 mg IV, then 20–80 mg every 10–30 min to a maximum cumulative dosage of 300 mg or constant infusion 1–2 mg/min IV	Tachycardia is less common with fewer adverse effects Avoid in women with asthma, preexisting myocardial disease, decompensated cardiac function, and heart block and bradycardia	1–2 min
Hydralazine	5 mg IV or IM, then 5–10 mg IV every 20–40 min to a maximum cumulative dosage of 20 mg or constant infusion 0.1–10 mg/min IV	Higher or frequent dosage associated with maternal hypotension, headaches, and abnormal fetal heart rate trackings; may be more common than other agents	10–20 min
Nifedipine (immediate release)	10–20 mg orally, repeat in 20 min if needed; then 10–20 mg every 2–6 h; maximum daily dose is 180 mg	May observe reflex tachycardia and headaches	5–10 min

Abbreviations: IM, intramuscularly; IV, intravenously.

Table 5
Serum magnesium concentration and toxicities

mmol/L	mEq/L	mg/dL	Effect
2–3.5	4–7	5–9	Therapeutic range
>3.5	>7	>9	Loss of patellar reflexes
>5	>10	>12	Respiratory paralysis
>12.5	>25	>30	Cardiac arrest

Data from Duley L.Magnesium Sulphate regimens for women with eclampsia: message from the Collaborative Eclampsia Trial. Br J Obstet Gynaecol 1996;103:103-5 and Lu Jf, Nightigale CH. Magnesium sulfate in eclampsia and pre-eclampsia: pharmacokinetic principles. Clin Pharmacokinet 2000;38:305-14.

From ACOG Practice bulletin number 222: Gestational Hypertension and Preeclampsia, June 2020.

sometimes up until one year postpartum. Therefore, even in a postpartum patient, preeclampsia should be considered and treated as such.

Severe Hypertension

It is especially important to pay attention to severe range blood pressures because these thresholds are different for pregnant and postpartum patients. If a patient has blood pressures that are severe they need to be addressed immediately, sometimes within minutes. Sustained severe range blood pressure within 15 minutes warrants treatment. There are several different antihypertensives that are given to control severe range blood pressures in pregnancy (see **Table 4**).[13] There is no one antihypertensive medication that is preferred over another to control severe hypertension in pregnancy.[17] The decision can be made clinically. For example, if a patient presents and does not have intravenous (IV) access, one could consider oral nifedipine for immediate treatment. However, for all these patients IV access is indicated and should be started as soon as possible.

Dosing should be continued if the blood pressure continues to be in the severe range (see **Table 4**).[13] Any pregnant patient who has severe range blood pressure is diagnosed with severe hypertension whether it is preeclampsia (now with severe features) or severe gestational hypertension. Whenever giving an antihypertensive for a patient with severe range blood pressures, magnesium sulfate should also be given secondary to the risk of eclampsia for seizure prevention.

Preventing Eclampsia

Once a patient develops preeclampsia with severe features, magnesium sulfate should be started for seizure prophylaxis. The usual dosage of magnesium sulfate is 4-6 g IVPB loading dose followed by 2 g/h IVPB.[18] Magnesium sulfate should be given intrapartum until birth, and then continued for 24 hours postpartum. When administering magnesium sulfate, attention must be paid to clinical signs of magnesium toxicity, including loss of deep patellar reflexes and respiratory depression.[18] Magnesium needs to reach a level for therapeutic treatment, but should be discontinued if there is concern for toxicity (see **Table 2**).[13]

EVALUATION AND WORKUP FOR HYPERTENSIVE PREGNANT AND POSTPARTUM PATIENTS

Keeping all the classifications for hypertension of pregnancy in mind, one must be on alert for any blood pressure elevations in a pregnant or postpartum patient.

Signs and Symptoms

Preeclampsia can present with one or more of the following both during pregnancy and the postpartum period:

- Headache
- Visual changes, including scotomata
- Epigastric and/or right upper quadrant pain
- Edema, dependent or otherwise
- Shortness of breath
- Chest pain
- Nausea and/or vomiting
- Hyperreflexia

Laboratory Values

The following laboratory tests may be helpful in determining the diagnosis:

- Complete blood cell count: thrombocytopenia
- Renal studies: elevated creatinine
- Liver function tests: twice the upper limit of normal range
- Coagulopathy
- Proteinuria: protein/creatinine urine ratio greater than 0.30 mg/dL or 24-hour urine collection for protein greater than 300 mg.

SUMMARY

Pregnant and postpartum patients with COVID-19 and hypertension may present differently than the general populations. These patients are at high risk, in particular while pregnant because fetal outcomes need to be considered; however, they are still vulnerable and at risk postpartum up to one year after delivery. There is an interesting correlation between the fact that pregnant patients with COVID-19, whether symptomatic or asymptomatic, have a high rate of hypertensive disorders. More than 60% of pregnancy-related deaths are considered preventable[19]; significant attention should be paid to the pregnant and postpartum populations.

CLINICS CARE POINTS

- An SpO2 of less than 95% is abnormal in pregnancy and requires assessment and treatment of both the maternal and fetal dyad.
- Remember that in caring for a pregnant woman, you are caring for TWO patients, three if a twin gestation.
- Magnesium sulfate loading dose for seizure prophylaxis is 4 or 6gm IVPB, after 2gm/hour IVPB.
- Blood pressure of greater or equal to 140 systolic or greater than or equal to 90 diastolic is abnormal in a pregnant woman and requires further evaluation.
- Blood pressures of greater than or equal to 160 systolic or greater than or equal to 110 diastolic is consistent with preeclampsia with severe features and requires both antihypertensive therapy and seizure prophylaxis if persistent.
- Contrary to popular belief that the "postpartum period" is six weeks, it actually persists for 12 months, and pregnancy complications must be considered in any woman presenting within that time frame.

DISCLOSURE

L.J. Stack has no disclosures to declare. A. Brady has no disclosures to declare.

REFERENCES

1. Society for Maternal-Fetal Medicine. Provider considerations for engaging in COVID-19 vaccine counseling with pregnant and lactating patients. 2022. Available at: http://www.smfm.org; https://www.smfm.org/covidclinical. Accessed February 21, 2022.
2. Society for Maternal-Fetal Medicine. Coronavirus (COVID-19) and Pregnancy: What Maternal-Fetal Medicine Subspecialists Need to Know. 2020. Available at: http://www.smfm.org; https://www.smfm.org/covidclinical. Accessed February 21, 2022.
3. Society for Maternal-Fetal Medicine and Society for Obstetric and Anesthesia and Perinatology. Labor and Delivery COVID-19 Considerations. 2020. Available at: http://www.smfm.org; https://www.smfm.org/covidclinical. Accessed February 21, 2022.
4. Sherer ML, Lei J, Creisher PS, et al. Pregnancy alters interleukin-1 beta expression and antiviral antibody responses during severe acute respiratory syndrome coronavirus 2 infection. Am J Obstet Gynecol 2021;225(3):301.e1-14.
5. PeriFACTS OB/GYN Academy. Activity # 22001P. Available at: http://www.urmc.rochester.edu/institute-innovative-education/center-experiential-learning/perifacts.aspx. January 2022. Accessed February 21, 2022.
6. ACOG Practice Bulletin No. 211: Critical Care in Pregnancy. Obstet Gynecol 2019;133(5):e303–19.
7. Metz TD, Clifton RG, Hughes BL, et al. Disease severity and perinatal outcomes of pregnant patients with coronavirus disease 2019 (COVID-19). Obstet Gynecol 2021;137(4):571.
8. Society for Maternal-Fetal Medicine. COVID-19 and Pregnancy: What Maternal-Fetal Medicine Subspecialists Need to Know. Available at http://www.smfm.org. Accessed January 10, 2022.
9. DeSisto CL, Wallace B, Simeone RM, et al. Risk for stillbirth among women with and without COVID-19 at delivery hospitalization—United States, March 2020–September 2021. Morbidity Mortality Weekly Rep 2021;70(47):1640.
10. Society for Maternal-Fetal Medicine. Management considerations for pregnant patients with COVID-19. 2020. Available at: http://www.smfm.org; https://www.smfm.org/covidclinical 2020. Accessed February 21, 2022.
11. Society for Maternal-Fetal Medicine. Practical Guidance for Treating Pregnant Persons With COVID-19 in Resource-Limited Settings: Early Lessons From the US Epidemic. 2020. Available at: http://www.smfm.org; https://www.smfm.org/covidclinical 2020. Accessed February 21, 2022.
12. Society for Maternal-Fetal Medicine. FDA Issues EUA for the Treatment of Mild-to-Moderate COVID-19. 2021. Available at: http://www.smfm.org; https://www.smfm.org/2021press. Accessed February 21, 2022.
13. American College of Obstetrics and Gynecology: Gestational Hypertension and Preeclampsia: Practice Bulletin Number 222, June 2020. Available at: https://www.acog.org/clinical/clinical-guidance/practice-bulletin/articles/2020/06/gestational-hypertension-and-preeclampsia. Accessed February 21, 2022.
14. Pregnancy Mortality Surveillance System. In: Center for Disease Control and Prevention. Available at: https://www.cdc.gov/reproductivehealth/maternal-mortality/pregnancy-mortality-surveillance-system.htm. Accessed February 21, 2022.

15. American College of Obstetrics and Gynecology: Hypertension, Clinical updates in Women's Health Care, January 2016. Available at: https://www.acog.org/clinical/journals-and-publications/clinical-updates/2016/01/hypertension. Accessed February 21, 2022.
16. American College of Obstetrics and Gynecology: Chronic Hypertension in Pregnancy: Practice Bulletin Number 203 January 2019. Available at: https://www.acog.org/clinical/clinical-guidance/practice-bulletin/articles/2019/01/chronic-hypertension-in-pregnancy. Accessed February 21, 2022.
17. Duley L, Meher S, Jones L. Drugs for treatment of very high blood pressure during pregnancy. Cochrane Database Syst Rev 2013;(7):CD001449.
18. Euser A, Cipolla M. Magnesium Sulfate treatment for the prevention of eclampsia: A brief review. Stroke 2009. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2663594/. Accessed February 21, 2022.
19. Building US. Capacity to Review and Prevent Maternal Deaths. Report from nine Maternal Mortality Review Committees 2018. https://www.cdcfoundation.org/sites/default/files/files/ReportfromNineMMRCs.pdf. Accessed February 21, 2022.