

**Intravenous Fluid Bolus Prior to Initiation of Epidural Analgesia in
Preeclamptic Patients**

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April 25, 2018

Presented to the Faculty at the University of Michigan-Flint
In partial fulfillment of the requirements for the
Doctor of Anesthesia Practice Program
(Spring/2018)

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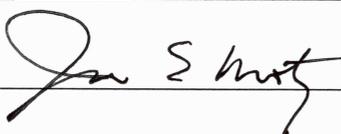
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Abstract

Purpose: The purpose of this project was to develop clear guidelines and increase safety for the preeclamptic parturients receiving labor epidurals and to protect their infants. Recommendations were elicited from seasoned practitioners of obstetrical (OB) anesthesia to establish parameters to guide fluid management decisions, recommend a specific volume range and type of fluid to be given, and recommend how best to treat hypotension caused by sympathectomy.

Methods: A cross-sectional survey design was used. Certified Registered Nurse Anesthetists from Michigan and Indiana who regularly provide OB anesthesia were asked multiple choice and open-ended questions via an online survey (Qualtrics) to elicit recommendations on caring for preeclamptic and severely preeclamptic parturients receiving a labor epidural.

Results: Nearly half (49.25%) of respondents recommended administering an IV fluid bolus prior to labor epidural placement in preeclamptic parturients. Another 44.78% listed factors such as blood pressure, fluid status, physical status or current symptoms, and renal function, as factors they consider before deciding on an IV fluid bolus. Both groups recommended administering an IV fluid bolus of 462 ml to 604 ml of a crystalloid solution. Twenty-six percent recommended treating hypotension in the preeclamptic parturient if mother or the fetus is symptomatic. Given a choice of multiple treatment options, over 75% of the experts recommended administering crystalloid, ephedrine, or phenylephrine to correct hypotension.

Conclusions: CRNAs experts in the field of high-risk OB responded overwhelmingly positively to pretreating a preeclamptic parturient with an IV fluid bolus prior to administering a labor epidural. Anesthesia providers should feel confident administering a modest IV fluid bolus to mitigate hypotension caused by vasodilation from a labor epidural.

Keywords: preeclampsia, labor epidural, fluid bolus, preload, hypotension.

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Introduction

Preeclampsia is a disorder specific to pregnancy that can lead to eclampsia, liver damage, stroke, pulmonary edema, or kidney failure, and growth restriction or preterm birth for the infant.¹ The National Institutes of Health estimate that three to five percent of pregnant women in the United States will develop preeclampsia.² Prevalence of preeclampsia has increased from 3.4% in 1980 to 3.8% in 2000. Rates of severe preeclampsia rose from 0.3% to 1.4% in the same time frame.³ The only known cure for preeclampsia is delivery of the fetus and placenta.⁴

Labor epidurals provide safe and effective analgesia for preeclamptic parturients.⁵ Experts advocate for these patients to receive labor epidurals.⁶⁻⁸ Epidural analgesia benefits the preeclamptic parturient by preventing dangerous blood pressure spikes caused by labor pains.⁶

In contrast to the benefit, epidural analgesia can cause low blood pressure in the parturient.⁹ Local anesthetic medication used in this procedure blocks sympathetic outflow to vasculature below the level of the block. Blocking normal sympathetic drive to the vasculature decreases the tone of vessel walls and increases their diameter. The end result is less blood volume returning to the heart, decreased cardiac output, and lower blood pressure.

The fetus's supply of oxygenated blood is totally dependent on the maternal systolic blood pressure. A decrease in the mother's blood pressure can cause the fetus to receive insufficient oxygenated blood.⁹ If not corrected, fetal heart rate will fall to dangerous levels and the obstetrician will be compelled to perform a cesarean section to provide supplemental oxygen to the baby.

Anesthesia providers typically manage epidural-induced hypotension in one of two ways, either with a bolus of intravenous (IV) fluids or administration of vasoconstrictors. A crystalloid bolus may be administered either just prior to initiating the epidural (preload) or in conjunction

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with epidural administration (coload). Intravenous fluid is well tolerated by parturients with a normal pregnancy but can have adverse effects for those with preeclampsia. The other method administering vasoactive medication at the time that hypotension occurs, has advantages and disadvantages.⁹ Vasopressors combat the decrease in systemic vascular resistance caused by labor epidurals.¹⁰ These medications increase maternal cardiac output and consequently fetal perfusion.¹¹ High doses of vasopressors, especially if combined with a vagolytic drug to combat low heart rate, can lead to dangerous hypertension with possible myocardial infarction or coronary artery dissection.¹¹

Preeclamptic parturients are at increased risk for developing pulmonary edema, which is a leading cause of morbidity and mortality in this population.^{12,13} Susceptibility to development of pulmonary edema in the preeclamptic parturient stems from proteinuria, permeable pulmonary vasculature, and increased hydrostatic pressure induced by the hypertensive disease.⁸ Fluid administration must be monitored closely as it can precipitate pulmonary edema.^{8,12} Iatrogenic fluid administration has been implicated as a cause.¹⁴

Best practice related to fluid administration prior to initiation of epidural analgesia in preeclamptic patients is not clearly defined in the literature. Some experts recommend avoiding additional fluids in these parturients^{1,6,7,15,16} while others recommend giving intravenous fluids.¹⁷⁻¹⁹ Experts who recommend giving fluid do so because vasodilation without an increase in cardiac output may cause decreased uterine perfusion.^{17,20} More hypotension and fetal heart rate abnormalities have been seen in severe preeclamptic parturients than normotensive parturients when given the same amount of IV preload prior to administering a labor epidural.²⁰ Consequently, anesthesia providers lack clear guidelines on fluid administration when providing

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preeclamptic parturients labor analgesia. Some experts warn that any extra intravenous fluid can lead to pulmonary edema while other experts state that one liter or more can be tolerated.¹³

Some experts believe that preeclamptic parturients demonstrate less hypotension from neuraxial anesthetics¹⁶ while others disagree.¹⁹ Those who believe preeclamptic parturients experience less hypotension use this reason to advocate for no fluid bolus.¹⁶ Experts who believe preeclamptic parturients become more hypotensive than non-preeclamptic patients advocate for administration of more than 500 ml intravenous fluid bolus and consider less to be insufficient.¹⁹

Knowledge is lacking on how the fetus responds to maternal hypotension induced by epidural analgesia. A prospective study showed no significant difference in fetal distress between preeclamptic and normotensive parturients related to initiation of epidural analgesia²¹. Conversely, a retrospective cohort study demonstrated an increase in fetal distress in severely preeclamptic parturients receiving epidural analgesia.¹⁹ One commonality of note in the previously cited studies, is that both studies used intravenous fluid preload prior to initiating epidural analgesia.

Conflict also exists on whether hypotension from epidural analgesia leads to an increase in cesarean section rates. One large study discovered no increase in cesarean sections²¹ while a smaller study found an increase.²⁰ However, the smaller study was underpowered to determine statistical significance.²²

Anesthesia providers are given conflicting recommendations from the literature, especially in regard to fluid administration for preeclamptic parturients. Few studies deal with labor epidural analgesia in the preeclamptic patient. The bulk of recommendations come from expert opinion.^{1,6,7,15-18} Some suggest that too little fluid can stress the fetus and lead to

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emergency cesarean section.¹⁹ Literature also reports that too much intravenous fluid given to preeclamptic patients, can cause life threatening pulmonary edema.^{12,14}

This doctoral project examined the recommendations of CRNAs practicing obstetrical anesthesia in Michigan and Indiana regarding IV fluid administration prior to insertion of epidural catheters in preeclamptic parturients. The goal was to develop clear guidelines to increase safety for preeclamptic parturients receiving labor epidurals and to protect their infants. The objectives were to elicit recommendations on the topic from seasoned practitioners of OB anesthesia, establish parameters to guide fluid management decisions, recommend a specific volume range and type of fluid to be given, and to make recommendations on how best to treat hypotension caused by sympathectomy. Answers to the following questions were sought.

1. What patient parameters are important in determining if anesthesia providers should give IV fluid to preeclamptic parturients before placing a labor epidural?
2. What type of IV fluid should anesthesia providers give to preeclamptic parturients before placing a labor epidural?
3. What volume of IV fluid should anesthesia providers give to preeclamptic parturients before placing a labor epidural?
4. Should anesthesia providers treat hypotension in an asymptomatic preeclamptic parturient or should symptoms in the mother or fetus trigger treatment?
5. What should anesthesia providers use to treat hypotension in a preeclamptic or severely preeclamptic parturient?

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Literature Review

Pathophysiology of Preeclampsia

In normal pregnancy, the placenta starts forming during the first week of gestation,²³ and the implanted embryo exists in a low oxygen environment. This state exists for the first 10 weeks at which time maternal vessels start to perfuse the placenta.²⁴ In response to the low oxygen state, the placenta releases cytotrophoblasts, cells involved in implanting the placenta into the uterine wall.²⁴ Cytotrophoblasts change the spiral arteries of the mother's uterus to allow more blood flow from the mother to the fetus.²⁴ The endothelial lining and smooth muscle layers of the spiral arteries are modified so that the distal end changes into the shape of a cone, decreasing resistance to blood flow to the placenta.^{4,24-26} This increased blood flow brings oxygen to the placenta causing a reduction in cytotrophoblast release.²⁴

The cause of preeclampsia is not well understood. One theory involves a two-stage process.^{4,24,25} In the first stage, altered spiral artery remodeling occurs and in the second stage the body reacts to the release of placental factors that cause endothelial damage.⁴ In preeclampsia, the cytotrophoblasts do not completely reshape the spiral arteries into the low resistance cone shape, this creates more resistance to blood flow to the placenta. Decreased blood flow results in the placenta receiving inadequate oxygen and eventually becoming ischemic.^{4,24-26} Existence of the ischemic placenta leads to the second stage of preeclampsia development. During the second stage of this theory, ischemia to the placenta triggers release of proinflammatory and antiangiogenic factors from the placenta that cause endothelial dysfunction throughout the mother's circulation.^{4,27} Angiogenic factors are substances that stimulate the creation of endothelial cells and new blood vessels.²⁸ Other factors hypothesized to be causative in preeclampsia are immune mediators²⁵, oxidative stress⁴, and the renin-angiotensin system.⁴ The

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end result is a parturient who develops high blood pressure with one or more of the following: excess protein in her urine, renal insufficiency, low platelet count, impaired liver function, pulmonary edema, or complaints of cerebral or visual disturbances.^{1,29}

Current research is focused on the renin-angiotensin system as possibly being the causative agent of hypertension in preeclampsia. Blood pressure is generally lower in normal pregnancy due to vasodilation,³⁰ resulting in decreased blood flow to the kidneys. The intrarenal baroreceptor pathway detects lower blood flow and signals renin release from the kidney's juxtaglomerular cells.³¹ Renin converts angiotensinogen, from the liver, into angiotensin I in the plasma. Angiotensinogen production is increased in pregnancy.³¹ Angiotensin I is converted to the potent vasoconstrictor, angiotensin II, by angiotensin converting enzyme in the lungs.³¹ Angiotensin II is a potent vasoconstrictor. Parturients demonstrate resistance to angiotensin II induced vasoconstriction during normal pregnancy.³⁰ Preeclamptic parturients, however, exhibit increased sensitivity to the vasoconstrictive effects of angiotensin II resulting in development of hypertension.³⁰

Proteinuria associated with preeclampsia is also not well understood.³⁰ Vascular endothelial growth factor (VEGF) maintains the integrity of glomerular capillaries thereby preventing some proteins from being excreted in the urine.³² The protein, sFlt1 is an antagonist of VEGF and in elevated amounts can disrupt glomerular capillary integrity.³² Protein enters the urine as the glomerular capillaries are unable to block their filtration. Increased serum levels of sFlt1 have been detected in preeclampsia.^{8,30,32} Levels of sFlt1 begin to increase late in the second trimester and can reach amounts that are as much as four times higher than in non-preeclamptic parturients.³⁰

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Renal insufficiency that is caused by preeclampsia is usually reversible. Renal blood flow and glomerular filtration are increased during normal pregnancy as a result of increase in plasma volume.³³ Renal blood flow and glomerular filtration are reduced in preeclampsia due to decreased plasma volume and resistance to flow in the renal afferent arterioles.³³ Increased levels of sFlt1, as seen in preeclampsia, can produce glomerular endotheliosis, which decreases the diameter of the renal afferent arteries and increases resistance to flow.³⁰ Renal injury in preeclamptic parturients is usually only seen when hypovolemic shock caused by hemorrhage and is inadequately treated.³⁴

Low platelet count, thrombocytopenia, occurs in half of parturients with preeclampsia.³⁵ The magnitude of thrombocytopenia equates to the severity the disease.³⁴⁻³⁶ In normal pregnancy, platelet counts decrease by about 10%, which is considered dilutional due to the increase in plasma volume.³⁶ Platelets are activated when they contact dysfunctional endothelium.³⁶ Platelet activation triggers increased platelet clearance causing thrombocytopenia in the parurient.³⁶

Liver impairment in pregnancy is always indicative of severe preeclampsia.³⁷ Hepatic hemorrhage and hepatic cellular necrosis cause liver damage but are rarely extensive enough to cause symptoms in the mother.³⁴ Serum levels of aspartate transferase and alanine transferase rise as the liver is damaged but the parturient may remain asymptomatic.³⁴

Preeclamptic parturients are susceptible to developing pulmonary edema. Endothelial damage caused by factors described previously lead to a more permeable vasculature in the lungs.^{12,38,39} Oncotic pressure that helps maintain fluid in the vasculature is lessened in normal pregnancy and even more so in preeclampsia.³⁸

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Preeclamptic headaches are caused by hyperperfusion of the cerebral vasculature.³⁴ The preeclamptic parturient may develop partial to full blindness that usually resolves when blood pressure is lowered or the patient receives intravenous magnesium sulfate.³⁴ There are two theories on how cerebral disturbances are manifested in the preeclamptic parturient. One postulates that severe hypertension leads to cerebral vasospasm and the subsequent decreased blood flow causes cerebral ischemia, edema, and ultimately infarction.²⁷ The other theory states that the severe cerebral hypertension increases hydrostatic pressure to the point of forcing plasma and red blood cells to cross the blood brain barrier causing encephalopathy.²⁷ Furthering the risk to the preeclamptic parturient is the condition of her blood brain barrier. Normal physiologic changes of pregnancy in addition to circulating factors created in preeclampsia appear to contribute to increased blood brain barrier permeability.²⁷

Diagnosis of Preeclampsia

The American College of Obstetricians and Gynecologists (ACOG) task force on hypertension in pregnancy published criteria for the diagnosis of preeclampsia in 2013.²⁹ Diagnosis is made when persistent high blood pressure develops after 20 weeks gestation and either systolic blood pressure is at or above 140 mmHg or diastolic blood pressure is 90 mmHg or higher. In addition to new onset high blood pressure, the patient has one of the following conditions: protein in the urine, platelet count less than 100,000/microliter (thrombocytopenia), serum creatinine equal to or greater than 1.1 mg/dl, doubling of pre-pregnancy creatinine level, serum liver transaminases twice normal values, pulmonary edema, cerebral disturbances, or visual disturbances.²⁹ Preeclampsia is considered severe when systolic blood pressure is 160mmHg or higher or diastolic blood pressure is 110 mmHg or higher. A patient is considered to have severe preeclampsia if they develop thrombocytopenia, renal insufficiency, liver

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impairment, pulmonary edema, or new onset cerebral or visual disturbances as mentioned previously.²⁹

Problem and Prevalence of Preeclampsia

Preeclampsia affects 3 to 5% of pregnancies in the United States and up to 8% worldwide.^{1,4} It is one of the leading causes of morbidity and mortality in both parturients and their infants.^{1,4,6} As the preeclamptic mother's blood pressure increases, so does her risk of suffering an intracerebral hemorrhage or stroke.⁸ In severe preeclampsia, blood flow to the placenta and fetus is also reduced. Compromised placental blood flow can lead to preterm delivery and birth of an infant that is small for gestational age.⁴⁰

History of Labor Epidurals

In 1909, Dr. Walter Stoeckel was first to describe epidural anesthesia for laboring mothers.⁴¹ Dr. Eugen Bogdan Aburel introduced the epidural catheter for labor anesthesia in 1931.⁴¹ These early obstetric epidurals were placed from the caudal approach and used procaine.⁴¹ Patients reported dissatisfaction with this technique because of a loss of motor function in the legs and poor reliability of the sensory block.⁴¹ Placement of an epidural catheter in the lumbar region began in 1949.⁴² Lumbar placement of the catheter became preferred over caudal placement in the 1960s because patients experienced less motor blockade.⁴¹

In the 1970s, epidural catheters were used to provide pain relief for a portion of the first stage of labor in addition to delivery.⁴¹ Lumbar epidurals are commonly used today to control pain from labor through delivery. ACOG released a statement in 2006 strongly supporting the use of labor epidurals for any mother who requests one and who does not have a medical contraindication.⁴³ Currently, low dose local anesthetic is frequently combined with a narcotic to

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produce effective pain relief, reduce the total amount of each drug used, and to minimize medication side effects.⁹

Epidural Use in Preeclampsia

The safe use of epidural analgesia for preeclamptic patients has been established.^{5,44} Low platelet count or presence of disseminated intravascular coagulation still precludes these patients from receiving an epidural.^{6,29} Other contraindications to labor epidural include: patient refusal, infection at the site of needle placement, a bleeding disorder, high intracranial pressure, severe hypovolemia, or severe stenosis of either the aortic or mitral valve.⁴⁵ Because of the sympathetic blockade produced, epidural analgesia helps prevent dangerous elevation of blood pressure in the preeclamptic parturient caused by her physiologic response to labor pain.⁶ Effective epidural analgesia blocks catecholamine release during painful contractions, improving blood flow to the placenta.^{8,20,40}

Fluid Management

The preeclamptic mother is at increased risk for developing pulmonary edema, which is a leading cause of mortality in these parturients.^{6,12} Fluid from the pulmonary vasculature enters the interstitial space and then the alveoli.⁴⁶ Fluid in the alveoli reduces the amount of oxygen that can be exchanged with the blood, resulting in insufficient oxygen delivery to vital organs.¹² Pulmonary edema has been reported in 0.08% to 0.5% of all pregnancies but occurs in 3% of mothers with preeclampsia.¹² Preeclampsia causes three physiologic changes that increase the risk for developing pulmonary edema. The preeclamptic patient loses protein in the urine resulting in less plasma oncotic pressure.^{12,17,47} It increases permeability of the endothelial layer of the vasculature, which allows fluid to cross more freely from the pulmonary capillaries to the interstitial space and alveoli,^{12,17,47} and the hypertension of preeclampsia causes more fluid to

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return to the heart. This increases hydrostatic pressure in the pulmonary vasculature.^{12,17} Fluid moves from a space of higher hydrostatic pressure to a space of lower hydrostatic pressure.⁴⁶ Increases in blood pressure and fluid volume can lead to the development of pulmonary edema.

Input and output of fluid should be closely monitored in preeclamptic patients. In a comparison of a hospital without a fluid policy for preeclamptic parturients to a hospital using a restrictive fluid policy, parturients were four times more likely to develop pulmonary edema if they received 10 liters of intravenous fluid during labor and delivery and 9.2 times more likely if 15 liters were given.¹⁴

Oliguria can occur if a patient has low plasma volume. It is a late sign of severe preeclampsia.⁴⁷ Oliguria may be the result of reduced blood flow or damage to the kidneys.¹⁷ One study showed that 52% of patients with severe preeclampsia and oliguria responded to a 500 ml fluid bolus of normal saline over 15 minutes with increased urine output.⁴⁸ Recommendations are varied on the treatment of oliguria in preeclampsia. Some experts recommend no fluid bolus to treat oliguria, stating that oliguria has not been shown to increase the incidence of renal failure.^{1,6,7,43} Other experts recommend treating oliguria with a modest fluid bolus, especially if the patient has negative fluid balance.^{15,17}

Current Recommendations

Current recommendation from the American Society of Anesthesiologists Task Force on Obstetric Anesthesia is that no amount of IV fluid is required prior to initiating labor epidural analgesia.⁴⁹ The guideline does not address the preeclamptic patient. The Royal College of Obstetricians and Gynaecologists from the United Kingdom (UK) and the Society of Obstetricians and Gynaecologists of Canada recommend that preeclamptic women not receive an IV fluid bolus prior to initiating a labor epidural.^{7,50} Other authors cite a lack of evidence

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supporting the use of IV fluid bolus to prevent hypotension and thus recommend against its use in preeclamptic patients.^{1,6,15}

Recommendation in favor of the use of an IV fluid bolus before initiation of a labor epidural can also be found in the literature.^{17,18,20} One author advocated giving 500 - 1000 ml of fluid bolus to avoid hypotension.¹⁸ Others suggest a smaller fluid bolus of 300 – 500 ml to avoid hypotension and decreased utero-placental perfusion.^{17,20} Yet another study found that severely preeclamptic patients experience more hypotension and more abnormalities in fetal heart tones, an indication of insufficient blood flow to the fetus, than normotensive controls receiving a labor epidural after a 500 ml fluid bolus.²⁰

The Society of Obstetricians and Gynaecologists of Canada (SOGC) state their recommendation for no intravenous fluid bolus prior to neuraxial anesthesia is based upon evidence obtained from at least one random controlled trial (RCT).⁵¹ They reference work published by Morgan⁵² stating that a fluid bolus will not prevent hypotension in healthy parturients receiving spinal anesthesia for cesarean section. Morgan actually concluded that a crystalloid preload is inconsistent in preventing hypotension.⁵² He cited three RCTs that support fluid bolus prior to spinal anesthetics for cesarean section and eight RCTs that concluded fluid bolus did not decrease hypotension.⁵² The RCTs cited by Morgan studied healthy parturients instead of preeclamptic parturients and evaluated spinal anesthetics instead of epidural analgesia. The SOGC, referencing a report on maternal deaths in the UK, recommend against fluid preloading in preeclamptic patients due to its potential to increase the risk of pulmonary edema.⁷ It is accepted that fluid overload in preeclamptic patients can lead to pulmonary edema. Of interest is that there were no obstetrical deaths from pulmonary edema from 1991 to 2008 in the UK report.⁵³

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The SOGC recommend treating hypotension from spinal anesthesia with either phenylephrine or ephedrine instead of a fluid bolus.⁷ They reference a systematic review evaluating these two vasopressors after spinal anesthesia for cesarean section in healthy parturients⁵⁴ which found no difference between the vasopressors in their ability to manage hypotension in this population and indirect evidence that phenylephrine led to better uterine blood flow.⁵⁴ All subjects in the referenced RCTs were healthy and received spinal anesthesia, not epidural analgesia. All of the RCTs included in this systematic review gave the parturients a fluid bolus ranging from 500 ml to 2,000 ml of crystalloid prior to initiating the spinal anesthetic.⁵⁴

NICE Guidelines

The National Institute for Health and Care Excellence (NICE) provides healthcare guidance to the United Kingdom. The NICE guideline authors recommend that no alterations in regional analgesia technique are needed for parturients with hypertensive disorders other than severe preeclampsia. They recommend not preloading severely preeclamptic women before administering low dose epidural analgesia. The authors base their recommendations on 3 RCTs (Table 1). These RCTs compared epidural analgesia to either intravenous or intramuscular analgesia for labor and delivery.^{21,55,56} All of the studies preloaded the epidural group with 250 ml to 540 ml of lactated Ringer's solution and all of the patients had either pregnancy induced hypertension, preeclampsia, or severe preeclampsia.^{21,55,56} The only incidence of pulmonary edema found was in severely preeclamptic parturients, but in equal numbers between the group of parturients that received a fluid bolus for an epidural and the group that did not receive extra fluid for epidural analgesia.⁵⁵

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Author	Sample	Preload	Findings
Patel et al. ²¹	100 preeclamptic parturients with epidural and 200 normotensive parturients with epidural	540 mL of lactated Ringer's solution	2% incidence of hypotension in the preeclamptic parturients and a 3% incidence of hypotension in the normotensive parturients. Overall, no statistically significant difference. None of the 100 preeclamptic parturients with epidural analgesia developed pulmonary edema.
Lucas et al. ⁵⁶	Parturients with pregnancy-induced hypertension. 372 received epidural analgesia and 366 received intravenous analgesia	500 mL of lactated Ringer's solution (epidural group only)	Mean arterial pressure was significantly lower in epidural group compared with intravenous group. 11% of epidural group required treatment of hypotension with ephedrine. Authors conclude that small doses of IV ephedrine will counteract hypotension caused by epidural. No parturients developed pulmonary edema.
Head et al. ⁵⁵	Parturients with severe preeclampsia. 56 received epidural analgesia and 60 received intravenous analgesia	250-500 mL of lactated Ringer's solution (epidural group only)	9% of the epidural group required treatment of hypotension with ephedrine compared to no parturients in the opioid group. Pulmonary edema occurred in one parturient in each group.

Table 1. RCTs recommending no preload per NICE

In a review of preeclampsia for anesthetists, administering a labor epidural in severely preeclamptic parturients with no extra intravenous fluid was recommended because observational studies demonstrated no benefit (table 2).⁶ The problem with this RCT to support the stance of avoiding fluid bolus for labor epidurals is that the hypotension created by medications in this study does not correlate with the rapid hypotension seen from epidural vasodilation.⁵⁷ The systematic review did not investigate the use of plasma volume expansion to avoid rapid hypotension from epidural vasodilation.⁵⁸ Trials that met inclusion criteria, even when added together, were underpowered to draw any conclusions about plasma volume expansion.⁵⁸

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Author	Sample	Preload	Findings
Ganzevoort et al. ⁵⁷	Parturients with severe preeclampsia, eclampsia, and HELLP receiving antihypertensive medication therapy. 111 patients received 250 mL of hydroxyethyl starch 6% twice daily, 105 in control group received no fluid bolus.	Fluid bolus done between 24 and 30 weeks gestation. Study did not look at anesthetics, as parturients were not delivering during study.	Correcting hypovolemia during antihypertensive medication therapy made no significant differences in neonatal cerebral and umbilical blood flow, in fetal growth, or in amniotic fluid.
Duley et al. ⁵⁸	Three trials of women with preeclampsia or hypertension during pregnancy (total of 61 parturients).	Fluid bolus done with colloid solutions. Studies did not look at anesthetics.	The trials were too small to make any reliable conclusions about the effects of plasma volume expansion for women with preeclampsia.

Table 2. No recommend preload per Dennis

Arulkumaran & Lightstone¹⁵ reported that even though parturients suffering from severe hypertension may be volume depleted, giving them a fluid bolus of up to 500 ml of crystalloid to prevent hypotension from vasodilation is not backed by clinical evidence.¹⁵ This recommendation is based on the previously cited RCT study by Ganzevoort et al. To reiterate, this RCT did not address preventing hypotension caused by epidural vasodilation.⁵⁷

Anesthesia providers are given conflicting recommendation from the literature, especially in regard to fluid administration for preeclamptic parturients. Some experts recommend giving these patients no IV fluid bolus because of the risk of causing life threatening pulmonary edema. Other experts recommend giving an IV fluid bolus because too little fluid can stress the fetus and lead to emergency cesarean section. There are very few RCTs that focus on giving IV fluid bolus to preeclamptic parturients prior to initiating a labor epidural. No RCTs compare different IV fluid volumes for this patient population. The RCTs that give a fluid bolus state it was done

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because of hospital protocol. Different parameters of the patients' condition that might drive decision-making have not been addressed.

While this project is not designed to conduct a random controlled trial, it will attempt to answer 1) which parameters CRNAs find important in deciding whether or not to give a fluid bolus to the preeclamptic parturient 2) what type and amount of fluid is recommended, and 3) when should post epidural hypotension be treated and with what?

Theoretical Model

The PEACE framework was developed at New York-Presbyterian Hospital (NYP) to implement Evidenced Based Practice (EBP) through out their hospital system. NYP evaluated five models of implementing EBP but found them complex and difficult to apply at the bedside.⁵⁹ They created a five-step process that included problem identification, evidence review, appraisal of evidence, changing practice or conducting research, and evaluation of practice changes or research findings.

Tahan et al. suggest using the PICO method to identify the problem.⁵⁹ The PICO method is used to develop a clear and answerable question.⁶⁰ PICO consists of defining the population, the intervention, the comparison intervention, and the outcome of interest.⁶⁰ The second step is to search the literature, especially within the past five years, for evidence-based practice related to the defined problem.⁵⁹ Appraising the evidence is next in the PEACE framework.⁵⁹ If evidence found is sufficient enough to compel a change in practice, the fourth step is to change practice.⁵⁹ If not, the fourth step becomes conduct of research.⁵⁹ The last step is to evaluate either the outcome of the practice change or to evaluate the research that was conducted.⁵⁹

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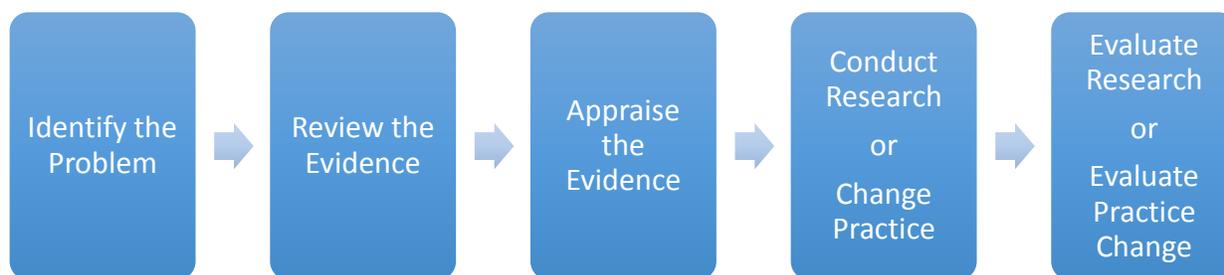


Figure 1. The PEACE Model

Materials and Methods

This study used a cross-sectional survey design. A cross-sectional survey elicits, “...current attitudes, beliefs, opinions, or practices.”⁶¹ The author obtained study approval from the University of Michigan-Flint Institutional Review Board (Appendix A). A 48-item survey (Appendix B) was administered using the Qualtrics program through the University of Michigan-Flint. CRNAs who regularly provide obstetrical anesthesia were asked multiple choice and open-ended questions to elicit their recommendations regarding IV fluid preload in preeclamptic and severely preeclamptic parturients receiving a labor epidural.

An email was sent to CRNAs who are members of the Michigan Association of Nurse Anesthetists (Appendix C) and the Indiana Association of Nurse Anesthetists (Appendix D) by their respective organizations. The email explained the purpose of the study, the voluntary nature of the study, offered reassurance that the participant will remain anonymous, and included a statement that the participant gives informed consent (Appendix E) by completing any of the survey questions. The email contained a link to the survey and contact information for participant questions. The survey remained open for five weeks. A follow up email was sent two and four weeks after the first email to remind potential participants of the time remaining until survey close.

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The Merriam-Webster dictionary defines an expert as someone that has or displays special skill or knowledge that is derived from training or experience.⁶² This study defined an expert as a nurse anesthetist that displays special knowledge through experience by currently working with high-risk parturients. The study also defined an expert as a nurse anesthetist that displays special knowledge by teaching or lecturing on the topic of anesthesia for high-risk parturients. The first three questions of the survey were used to determine inclusion status of the participant.

Inclusion criteria were CRNAs who have provided anesthesia services to high-risk parturients for more than 2 years within the past 5 years. CRNAs that indicated they teach or lecture on anesthesia for high-risk OB patients were also included. Exclusion criteria included respondents that have provided anesthesia services to high-risk parturients for less than 2 years within the past 5 years. CRNAs that did not meet the practice standard described in the inclusion criteria and do not teach or lecture on anesthesia for high-risk patients were excluded. Participants' anonymity was protected by not collecting personal or identifying information by the Qualtrics program or the survey questions.

Implementation

Managers for the Michigan Association of Nurse Anesthetists and the Indiana Association of Nurse Anesthetists emailed a request for survey completion to their current members during the first week of January 2018. They sent follow-up emails on January 15, 2018 and January 29, 2018 reminding members that the survey was still open. The survey was closed to respondents on February 7, 2018. Qualtrics survey software, licensed through the University of Michigan-Flint, recorded and stored the responses. The collected data was analyzed with the assistance of this software.

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ResultsDemographics

An initial email was sent out to 2,467 MANA CRNAs and 419 INANA CRNAs requesting participation in this survey. A follow-up email was sent two weeks later and a third two weeks after the second. The survey remained open for one week following the third email. There were 250 responses received for a total response rate of 8.66%. The number of respondents meeting inclusion criteria was 76. All of these respondents indicated they had provided high-risk OB services in the last 2 to 5 years except one that met inclusion by indicating they teach or lecture on high-risk OB. Specific demographics of the respondents are depicted in Table 3.

	N	%
Gender		
Female	36	47.37%
Male	22	28.95%
Did not indicate	18	23.68%
State of practice		
Indiana	13	17.11%
Michigan	46	60.53%
Did not indicate	17	22.37%
Years of practice		
0-5 years	7	9.21%
6-10 years	6	7.89%
11-15 years	11	14.47%
16-20 years	12	15.79%
21 or more years	22	28.95%
Did not indicate	18	23.68%

CRNA experts responded to statements regarding variables that may influence their decision to administer IV fluids to preeclamptic or severely preeclamptic parturients prior to initiating a labor epidural (Table 4). Ordinal values one through five were given to responses on the Likert-type scale from strongly disagree = 1 to strongly agree = 5. Three variables that most

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influence these CRNAs decision to deliver IV fluids are the presence of pulmonary edema, the presence of cerebral or visual disturbances, and presence of renal insufficiency (Table 4).

Table 4. Variables that are important to determine type and amount of fluid bolus for preeclamptic or severely preeclamptic parturients

Variable	Strongly Agree (5)	Agree (4)	Neither agree nor disagree (3)	Disagree (2)	Strongly disagree (1)	Mean
Patient's fluid balance (recorded input and output values)	12/ 16.67%	40/ 55.56%	13/ 18.06%	7/ 9.72%	0/ 0%	3.79
Patient's current blood pressure measurement	8/ 11.11%	46/ 63.89%	12/ 16.67%	6/ 8.33%	0/ 0%	3.78
Presence of proteinuria	9/ 12.50%	21/ 29.17%	28/ 38.89%	13/ 18.06%	1/ 1.39%	3.33
Presence of renal insufficiency	17/ 23.61%	48/ 66.67%	5/ 6.94%	2/ 2.78%	0/ 0%	4.11
Presence of impaired liver function	9/ 12.50%	22/ 30.56%	26/ 36.11%	14/ 19.44%	1/ 1.39%	3.33
Presence of pulmonary edema	44/ 61.11%	25/ 34.72%	3/ 4.17%	0/ 0%	0/ 0%	4.57
Presence of cerebral or visual disturbances	30/ 41.67%	26/ 36.11%	11/ 15.28%	5/ 6.94%	0/ 0%	4.13

Note: Bold number = actual number of respondents, non-bold number = percentage of total respondents. 72 respondents answered these questions.

Normotensive Parturients

The majority of respondents recommend administering an IV fluid bolus prior to labor epidural placement in normotensive parturients (Appendix F). Those that recommend an IV fluid

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bolus all suggest giving a crystalloid solution in the range of 709 ± 254 ml to 883 ± 291 ml.

Respondents that stated a patient factor would influence their decision listed the patient's fluid status (40%) and current blood pressure measurements (30%) as most important factors to consider. Experts that listed patient factors to consider prior to delivering a fluid bolus recommend less volume (650 ± 229 ml to 700 ± 245 ml). A small percentage (7.25%) of the respondents did not recommend administering IV fluid prior to starting a labor epidural.

Preeclamptic Parturients

Almost half (49.25%) of respondents recommend administering an IV fluid bolus prior to labor epidural placement in preeclamptic parturients where a small group (5.97%) recommend against this practice (Appendix G). Those that recommend an IV fluid bolus all suggest giving a crystalloid solution but in a more conservative volume than normotensive parturients (556 ± 283 ml to 672 ± 309 ml). Forty-four percent of respondents (44.78%) listed factors they would consider before deciding on an IV fluid bolus. Blood pressure (33.33%), fluid status (20%) physical status or current symptoms (16.67%), and renal function (13.33%) were mentioned most frequently as factors that should be considered. Experts that suggested evaluating factors prior to delivering a fluid bolus recommend more conservative volumes (303 ± 209 ml to 489 ± 220 ml).

Severely Preeclamptic Parturients

Over half of respondents (54.10%) listed factors they would consider before deciding to administer an IV fluid bolus prior to labor epidural placement in severely preeclamptic parturients (Appendix H). The factors most recommended were blood pressure (36.36%), fluid status (24.24%), physical status or current symptoms (24.24%), renal function (12.12%), and respiratory function (12.12%). Some respondents (29.51%) would recommend an IV fluid bolus

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for these parturients. Those who would administer a fluid bolus recommend an IV fluid bolus of a crystalloid solution in the range of 656 ± 398 ml to 736 ± 395 ml. Only one respondent recommended administration of colloid solution for a fluid bolus and it was only for the severely preeclamptic parturients after considering other factors. Experts that suggested evaluating factors prior to delivering a fluid bolus to the severely preeclamptic parturient recommended lower volumes (346 ± 190 ml to 500 ± 159 ml). The average recommended volume was higher for the severely preeclamptic parturient than the preeclamptic parturient. When comparing individual expert recommendations, only 10% recommended a larger fluid bolus be administered to the severely preeclamptic parturient. The majority of experts were more conservative either recommending lower volumes (30%) or the same volume (58%) administered to the more severe parturient. One expert recommended a wider range of fluid volume with a more conservative minimum and a more liberal maximum.

Fluid Recommendations from Those Who Teach or Lecture on High-risk OB Anesthesia

Four of the 76 CRNAs meeting inclusion criteria indicated they teach or lecture on high-risk OB anesthesia. They all recommend giving an IV fluid bolus prior to labor epidural placement in all three groups of parturients (Appendix I). The respondents that specified a fluid type (75%) all recommended lactated Ringer's solution. Some teacher/lecturers recommended a smaller fluid volume for preeclamptic and severely preeclamptic parturients than normotensive parturients.

Treating Hypotension

Fifty of fifty-eight CRNAs recommend treating a preeclamptic parturient who experiences hypotension. Over 90% of the respondents would treat this hypotension if the preeclamptic parturient or the fetus were symptomatic (Table 5). Given the choice of multiple

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treatment options, over 75% of the experts specified administering crystalloid, ephedrine, or phenylephrine to correct the hypotension. Eight respondents (16%) recommended infusing colloid fluid.

Forty-seven CRNAs recommend treating a severely preeclamptic parturient who experiences hypotension. The majority of respondents recommend treating hypotension if the parturient is symptomatic (93.6%) or the fetus is symptomatic (89.4%). CRNAs again recommended administering crystalloid, ephedrine, or phenylephrine to correct the hypotension in the severely preeclamptic parturient.

Table 5. Recommendations on when and how to treat hypotension in preeclamptic and severely preeclamptic parturients

If the preeclamptic parturient experiences hypotension, which of the following would cause you to treat the hypotension? (choose all that apply).	If the parturient is symptomatic	46 / 92.0%
	If the parturient is NOT symptomatic	13 / 26.0%
	If the fetus is symptomatic	47 / 94.0%
	If the fetus is NOT symptomatic	8 / 16.0%
What do you recommend anesthesia providers use to treat hypotension in preeclamptic parturients? (choose all that apply)	Crystalloid	37 / 74.0%
	Colloid	8 / 16.0%
	Ephedrine	39 / 78.0%
	Phenylephrine	39 / 78.0%
	Other recommendation	1 / 2.0%
If the severely preeclamptic parturient experiences hypotension, which of the following would cause you to treat the hypotension? (choose all that apply).	If the parturient is symptomatic	44 / 93.6%
	If the parturient is NOT symptomatic	16 / 34.0%
	If the fetus is symptomatic	42 / 89.4%
	If the fetus is NOT symptomatic	7 / 14.9%
What do you recommend anesthesia providers use to treat hypotension in severely preeclamptic parturients? (choose all that apply)	Crystalloid	32 / 69.6%
	Colloid	6 / 13.0%
	Ephedrine	34 / 73.9%
	Phenylephrine	37 / 80.4%
	Other recommendation	1 / 2.2%

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Discussion

National guidelines^{50,51} either recommend avoiding IV fluid bolus prior to administering a labor epidural in preeclamptic parturients or they are silent on the issue.^{29,49} Recent articles are recommending administration of a fluid bolus in this situation.¹⁷⁻¹⁹ The CRNA experts who participated in this survey either recommended giving the preeclamptic parturient an IV fluid bolus outright (49.25%) or giving it if certain factors are present (44.78%). The two most frequently listed factors were the parturients' blood pressure measurements and fluid status. Only a small percentage (5.97%) recommend avoiding an IV fluid bolus (Table 8). As the parturient exhibits greater disease severity, recommendations become more conservative. Almost thirty percent (29.51%) of the experts would still recommend giving an IV fluid bolus to a parturient experiencing **severe** preeclampsia and requesting a labor epidural. Sixteen percent (16.39%) advise avoiding a fluid bolus in this group. More than half (54.10%) of the experts recommend a fluid bolus based on presence of defined factors. The factors most recommended were the parturients' blood pressure measurements, fluid status, and physical status or current symptoms (Table 10).

There was strong consensus on the type of IV fluid recommended for the bolus. All the recommendations for preeclamptic parturients were for crystalloid solutions. All but one of the recommendations for severely preeclamptic parturients was for crystalloid solutions.

We chose to let the CRNA experts list their recommendation for IV fluid volumes. Respondents offered a wide range of volumes. Since most responses listed a range of volumes, the mean was calculated for both the low end and high end of their recommended ranges. The CRNAs that recommended giving an IV fluid bolus to preeclamptic parturients listed a volume range of 556 ± 283 ml to 672 ± 309 ml. The experts recommending an IV fluid bolus only if

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certain parameters were met, suggested a more conservative volume range of 303 ± 209 ml to 489 ± 220 ml (Table 9). If the parturient was experiencing severe preeclampsia, the experts who recommend a fluid bolus suggested a range of 656 ± 398 ml to 736 ± 395 ml. Even though the calculated volumes were higher for the severely preeclamptic parturient, most of the experts recommended administering the same or lower volume when compared to preeclamptic parturients. Those experts suggesting certain parameters need to be met before giving an IV fluid bolus recommended a volume range of 346 ± 190 ml to 500 ± 159 ml (Table 11). These volume ranges are similar to the recommendations found in the literature from advocates of administering an IV fluid bolus prior to initiating a labor epidural in preeclamptic and severely preeclamptic parturients.^{17,18,20}

This study sought patient parameters deemed important considerations when determining if a preeclamptic parturient should receive an IV fluid bolus. According to our CRNA experts, the three most important variables were the presence of pulmonary edema, the presence of cerebral or visual disturbances, and presence of renal insufficiency. These variables all had a mean score greater than four on a Likert-type scale (agree or strongly agree) (Table 4).

We asked if anesthesia providers should treat hypotension in an asymptomatic preeclamptic parturient. Respondents were allowed to choose multiple situations in which they would recommend treating hypotension. A small percent (26%) would recommend treating an asymptomatic preeclamptic parturient. The majority of experts would treat the preeclamptic parturient if she was symptomatic (92%) or if the fetus was symptomatic (94%). When asked the same question about treating a severely preeclamptic parturient, the CRNA experts had similar responses. Slightly more (34%) would recommend treating an asymptomatic severely preeclamptic parturient. About ninety-four percent (93.6%) recommend treating hypotension if

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the severely preeclamptic parturient is symptomatic and 89.4% recommend treating if the fetus is symptomatic.

When asked how to treat hypotension in preeclamptic and severely preeclamptic parturients, respondents indicated, hypotension in the preeclamptic parturient should be treated with IV ephedrine (78%), IV phenylephrine (78%), or IV crystalloid solution (74%). Sixteen percent of experts recommended treating the hypotension with IV colloid and one expert recommended changing the parturient's position to lateral. The recommendations were similar for treating the severely preeclamptic parturient. The majority listed IV ephedrine (73.9%), IV phenylephrine (80.4%), or IV crystalloid solution (69.6%) as methods recommended to treat hypotension. Only thirteen percent recommended treating the hypotensive severely preeclamptic parturient with IV colloid and one recommended changing the parturient's position to lateral.

Study Limitations

A convenience sample was chosen for this study. The survey was only distributed to two states in the same section of the country. Including experts from different parts of the United States or even providers in different countries could change the recommendations. Also, we used a broad definition of "expert", defined as someone that has or displays special skill or knowledge that is derived from training or experience.⁶² In our study, respondents were considered an expert if they delivered anesthesia to high-risk OB patients for two of the last five years or they taught anesthesia for high-risk OB as a subject matter expert. A more restrictive definition would have qualified fewer respondents and possibly changed the results. Patient outcomes were not measured in this study. Therefore, we cannot make any conclusions about best practice regarding fluid preload or hypotension treatment. The results only reflect the beliefs of CRNAs that

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completed the survey. The number of people not responding to a survey increases the chance for bias as the nonresponse group may hold different beliefs than the response group.⁶³

Project Dissemination

The results of this study will be presented in poster form. A Michigan Association of Nurse Anesthetists conference and an Indiana Association of Nurse Anesthetists conference were chosen due to their assistance in the survey distribution. Additional dissemination will be sought by possible poster presentation at the American Association of Nurse Anesthetists (AANA) annual conference, publication in the AANA journal, or publication in Anesthesia eJournal (www.anesthesiaejournal.com).

Conclusion

Fluid administration in the preeclamptic parturient requires caution due to the increased chance of pulmonary edema.⁶ Hypotension from the vasodilation caused by labor epidurals can be detrimental to the fetus.¹⁹ CRNAs experts in the field of high-risk OB responded overwhelmingly positively to pretreating a preeclamptic parturient with an IV fluid bolus prior to administration of a labor epidural to mitigate maternal hypotension. Ninety-four percent of the experts recommended a fluid bolus either outright or after evaluation of maternal factors such as blood pressure, fluid status, physical status, or current symptoms. These experts recommended giving an IV crystalloid solution in the 462 ± 285 ml to 604 ± 293 ml range (Table 9). Similarly, most of the respondents (83.6%) would consider an IV fluid bolus for the severely preeclamptic parturient either outright or after evaluation of maternal condition. Again, crystalloid was the fluid recommended in a volume range of 475 ± 333 ml to 599 ± 306 ml (Table 11). Even though the average volumes were higher for the severely preeclamptic parturient, closer examination of

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individual recommendations revealed most of the experts recommend administering the same or lower volume when compared to preeclamptic parturients.

The majority of the CRNA experts recommend treating hypotension in the preeclamptic or severely preeclamptic parturient if the patient or fetus is symptomatic. Some do recommend correcting hypotension even if the parturient is not exhibiting symptoms if she is preeclamptic (26%) or severely preeclamptic (34%). Correcting the hypotension with ephedrine, phenylephrine, or crystalloid was recommended.

Future research in this area may include surveying experts from other regions of the United States and from other countries to find out if regional differences change the recommendations. Conducting a randomized controlled study on how different volumes of IV fluid preload effect the incidence of hypotension in the severely preeclamptic parturient receiving a labor epidural would be extremely helpful.

Based on these expert recommendations, anesthesia providers should feel confident to consider administering a 462 ml to 604 ml crystalloid IV fluid bolus prior to providing a preeclamptic a labor epidural. Providers should evaluate maternal factors such as blood pressure, fluid status, physical status, or current symptoms to determine the appropriateness of a fluid bolus. When hypotension occurs in the preeclamptic parturient, treatment should include ephedrine, phenylephrine, or crystalloid fluid, even if the patient is not symptomatic.

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Appendix A: IRB approval email

To: Bradley Stelflug

From:

Kazuko Hiramatsu

Cc:

Jane Motz, Shawn Fryzel, Bradley Stelflug

Subject: Notice of Exemption for [HUM00138171]

SUBMISSION INFORMATION:

Title: Intravenous Fluid Bolus Prior to Initiation of Epidural Analgesia in Severely Preeclamptic Patients

Full Study Title (if applicable): Intravenous Fluid Bolus Prior to Initiation of Epidural Analgesia in Severely Preeclamptic Patients

Study eResearch ID: HUM00138171

Date of this Notification from IRB: 12/5/2017

Date of IRB Exempt Determination: 12/5/2017

UM Federalwide Assurance: FWA00004969 (For the current FWA expiration date, please visit the UM HRPP Webpage)

OHRP IRB Registration Number(s): IRB00000248

IRB EXEMPTION STATUS:

The IRB Flint has reviewed the study referenced above and determined that, as currently described, it is exempt from ongoing IRB review, per the following federal exemption category:

EXEMPTION #2 of the 45 CFR 46.101.(b):

Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Note that the study is considered exempt as long as any changes to the use of human subjects (including their data) remain within the scope of the exemption category above. Any proposed changes that may exceed the scope of this category, or the approval conditions of any other non-IRB reviewing committees, must be submitted as an amendment through eResearch.

Although an exemption determination eliminates the need for ongoing IRB review and approval, you still have an obligation to understand and abide by generally accepted principles of responsible and ethical conduct of research. Examples of these principles can be found in the Belmont Report as well as in guidance from professional societies and scientific organizations.

SUBMITTING AMENDMENTS VIA eRESEARCH:

You can access the online forms for amendments in the eResearch workspace for this exempt study, referenced above.

ACCESSING EXEMPT STUDIES IN eRESEARCH:

Click the "Exempt and Not Regulated" tab in your eResearch home workspace to access this exempt study.

Kazuko Hiramatsu

Chair, IRB Flint

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Appendix B: Survey Tool

AS YOU COMPLETE THE SURVEY, PLEASE USE THE FOLLOWING DEFINITIONS FOR PREECLAMPSIA AND SEVERE PREECLAMPSIA FROM THE AMERICAN CONGRESS OF OBSTETRICIANS AND GYNECOLOGISTS.

Diagnostic Criteria for PREECLAMPSIA

High Blood pressure

- Greater than or equal to 140 mm Hg systolic or greater than or equal to 90 mm Hg diastolic on two occasions at least 4 hours apart after 20 weeks of gestation in a woman with a previously normal blood pressure
- Greater than or equal to 160 mm Hg systolic or greater than or equal to 110 mm Hg diastolic, hypertension can be confirmed within a short interval (minutes) to facilitate timely antihypertensive therapy

and

Proteinuria

- Greater than or equal to 300 mg per 24 hour urine collection (or this amount extrapolated from a timed collection)
- or
- Protein/creatinine ratio greater than or equal to 0.3*
- Dipstick reading of 1+ (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/microliter

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

Cerebral or visual symptoms

* Each measured as mg/dL.

Definition of SEVERE PREECLAMPSIA

High Blood Pressure

- Systolic blood pressure of 160 mm Hg or higher, or diastolic blood pressure of 110 mm Hg or higher on two occasions at least 4 hours apart while the patient is on bed rest (unless antihypertensive therapy is initiated before this time)

Thrombocytopenia

- Platelet count less than 100,000/microliter

Impaired liver function

- Abnormally elevated blood concentrations of liver enzymes (to twice normal concentration), severe persistent right upper quadrant or epigastric pain unresponsive to medication and not accounted for by alternative diagnoses, or both

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Progressive renal insufficiency

- Serum creatinine concentration greater than 1.1 mg/dL or a doubling of the serum creatinine concentration in the absence of other renal disease

Pulmonary edema

New-onset cerebral or visual disturbances

Reference: ACOG task force report, "Hypertension in Pregnancy", issued November 14, 2013

Survey Questions

1. Do you provide anesthesia to high-risk obstetrical (OB) patients?

- Yes
- No

2. Have you provided labor epidural analgesia to high-risk OB for more than 2 years within the past 5 years?

- Yes
- No

In regards to a preeclamptic or severely preeclamptic parturient, please indicate the response that most closely represents the degree to which you agree with the following statements.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
3. I believe that using the patient's fluid balance (recorded input and output values) is important in determining the amount and type of IV fluid to give before placing a labor epidural.	<input type="radio"/>				
4. I believe that consideration of the patient's current blood pressure measurement is important in determining the amount and type of IV fluid to give before placing a labor epidural.	<input type="radio"/>				
5. I believe that consideration of the presence of proteinuria is important in determining the amount and type of IV fluid to give before placing a labor epidural.	<input type="radio"/>				
6. I believe that consideration of the presence of renal insufficiency is important in determining the amount and type of IV fluid to give before placing a labor epidural.	<input type="radio"/>				
7. I believe that consideration of the presence of impaired liver function is important in determining the amount and	<input type="radio"/>				

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type of IV fluid to give before placing a labor epidural.					
8. I believe that consideration of the presence of pulmonary edema is important in determining the amount and type of IV fluid to give before placing a labor epidural.	<input type="radio"/>				
9. I believe that the presence of cerebral or visual disturbances is important in determining the amount and type of IV fluid to give before placing a labor epidural.	<input type="radio"/>				

10. Do you believe that an intravenous fluid bolus prior to epidural analgesia reduces the incidence of hypotension in **non-preeclamptic** patients?

- Yes
- No
- Maybe, it depends on certain factors.

11. Complete this sentence: Whether or not I give a fluid bolus prior to initiating epidural analgesia in a non-preeclamptic patient depends on:

12. Do you recommend anesthesia providers give an IV fluid bolus prior to labor epidural placement in **normotensive** parturients?

- No
- Maybe, it depends on certain factors.
- Yes

13. Complete this sentence: Whether or not I give a fluid bolus prior to placing an epidural in **normotensive parturients** depends on:

14. If you administer a fluid bolus prior to placing an epidural in a **non-preeclamptic** parturient, do you recommend crystalloid or colloid?

- Crystalloid
- Colloid

15. If you recommend a crystalloid bolus prior to placing an epidural in a **non-preeclamptic** parturient, please indicate the type of solution you administer.

16. If you recommend a crystalloid bolus prior to placing an epidural in a **non-preeclamptic** parturient, please indicate the volume you administer.

17. If you recommend a colloid bolus prior to placing an epidural in a **non-preeclamptic** parturient, please indicate the type of solution you administer.

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18. If you recommend a colloid bolus prior to placing an epidural in a **non-preeclamptic** parturient, please indicate the volume you administer.

19. Do you recommend anesthesia providers give an IV fluid bolus prior to labor epidural placement in **preeclamptic** parturients?

- Yes
- No
- Maybe, it depends on certain factors.

20. I believe the appropriate type and amount of IV fluid to be administered to a **preeclamptic parturient** prior to placing an epidural depends on:

21. If you administer a fluid bolus prior to placing an epidural in a **preeclamptic parturient**, do you recommend crystalloid or colloid?

- Crystalloid
- Colloid

22. If you recommend administering a crystalloid bolus prior to placing a labor epidural in **preeclamptic patients**, please indicate the type of solution you administer.

23. If you recommend administering a crystalloid bolus prior to placing a labor epidural in **preeclamptic patients**, please indicate the volume you administer.

24. If you recommend administering a colloid bolus prior to placing a labor epidural in **preeclamptic patients**, please indicate the type of solution you administer.

25. If you recommend administering a colloid bolus prior to placing a labor epidural in **preeclamptic patients**, please indicate the volume you administer.

26. Do you recommend anesthesia providers give an IV fluid bolus prior to labor epidural placement in **severely preeclamptic** parturients?

- Yes
- No
- Maybe, it depends on certain factors.

27. I believe the appropriate type and amount of IV fluid to be administered to a **severely preeclamptic parturient** prior to placing an epidural depends on:

28. If you administer a fluid bolus prior to placing an epidural in severely preeclamptic parturients, do you recommend crystalloid or colloid?

- Crystalloid
- Colloid

29. If you recommend a crystalloid bolus prior to placing an epidural in a **severely preeclamptic parturient**, please indicate the type of solution you administer.

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30. If you recommend a crystalloid bolus prior to placing an epidural in a **severely preeclamptic parturient**, please indicate the volume you administer.
31. If you recommend a colloid bolus prior to placing an epidural in a **severely preeclamptic parturient**, please indicate the type of solution you administer.
32. If you recommend a colloid bolus prior to placing an epidural in a **severely preeclamptic parturient**, please indicate the volume you administer.
33. If the **preeclamptic** parturient experiences hypotension (greater than 20% drop in either systolic or diastolic blood pressure) do you recommend treating the parturient?
- Yes
 - No
34. If the **preeclamptic** parturient experiences hypotension (greater than 20% drop in either systolic or diastolic blood pressure) which of the following would cause you to treat the hypotension? (choose all that apply).
- If the parturient is symptomatic
 - If the parturient is NOT symptomatic
 - If the fetus is symptomatic
 - If the fetus is NOT symptomatic
35. What do you recommend anesthesia providers use to treat hypotension in **preeclamptic** parturients? (choose all that apply).
- Crystalloid
 - Colloid
 - Ephedrine
 - Phenylephrine
 - Other recommendation _____
36. If the **severely preeclamptic** parturient experiences hypotension (greater than 20% drop in either systolic or diastolic blood pressure) do you recommend treating the parturient?
- Yes
 - No
37. If the **severely preeclamptic** parturient experiences hypotension (greater than 20% drop in either systolic or diastolic blood pressure) which of the following would cause you to treat the hypotension? (choose all that apply).
- If the parturient is symptomatic
 - If the parturient is NOT symptomatic
 - If the fetus is symptomatic
 - If the fetus is NOT symptomatic
38. What do you recommend anesthesia providers use to treat hypotension in **severely preeclamptic** parturients? (choose all that apply).
- Crystalloid

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- Colloid
 - Ephedrine
 - Phenylephrine
 - Other recommendation _____
39. Do you teach or lecture on anesthesia for high-risk OB patients?
- Yes
 - No
40. If you teach or lecture on high risk OB anesthesia, what type and volume of IV fluid do you instruct students to administer prior to placing a labor epidural in **non-preeclamptic** parturients?
41. If you teach or lecture on high risk OB anesthesia, what type and volume of IV fluid do you instruct students to administer prior to placing a labor epidural in **preeclamptic** parturients?
42. If you teach or lecture on high risk OB anesthesia, what type and volume of IV fluid do you instruct students to administer prior to placing a labor epidural in **severely preeclamptic** parturients?
43. What do you teach anesthesia providers to use to treat hypotension in **non-preeclamptic** parturients? (choose all that apply)
- Crystalloid
 - Colloid
 - Ephedrine
 - Phenylephrine
 - Other recommendation _____
44. What do you teach anesthesia providers to use to treat hypotension in **preeclamptic** parturients? (choose all that apply)
- Crystalloid
 - Colloid
 - Ephedrine
 - Phenylephrine
 - Other recommendation _____
45. What do you teach anesthesia providers to use to treat hypotension in **severely preeclamptic** parturients? (choose all that apply)
- Crystalloid
 - Colloid
 - Ephedrine
 - Phenylephrine
 - Other recommendation _____
46. In which state do you practice?
- Michigan
 - Indiana

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47. How many years have you been practicing as a nurse anesthetist?

- 0-5 years
- 6-10 years
- 11-15 years
- 16-20 years
- 21 or more years

48. Please indicate your gender.

- Male
- Female

Thank you for participating in this survey!

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Appendix C: Email to MANA members

As a graduate student in the University of Michigan-Flint, Doctor of Anesthesia Practice program, I invite you to participate in a research project by taking a few minutes to complete the following survey.

The project is titled, "Intravenous Fluid Bolus Prior to Initiation of Epidural Analgesia in Severely Preeclamptic Patients." This study will use a cross-sectional survey design to elicit nurse anesthetist opinion about fluid administration and treatment of hypotension in obstetrical patients during labor. This project's goal is to understand the current thinking of nurse anesthetists who practice obstetrical anesthesia regarding hypotension prevention and treatment in preeclamptic parturients receiving epidural analgesia.

The survey consists of approximately 43 questions and should take no more than 13 minutes to complete. Your participation will provide valuable information. To protect participant privacy, all responses are anonymous. You are not required to answer every question. Answering one or more survey questions implies your consent to participate in this project.

The IRB Project Coordinator can be reached at the University of Michigan-Flint Office of Research at 810-762-3383 or by email at research@umflint.edu. For specific questions pertaining to the survey/project, please contact primary researcher Bradley Stelflug at 812-243-7994 or bstelflu@umflint.edu.

Thank you for your anticipated participation,

Brad Stelflug CRNA, MSN, FAAPM

[Begin Survey](#)

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Appendix D: Email to INANA members

A member of the INANA requests your assistance to complete his DNAP.

As a graduate student in the University of Michigan-Flint, Doctor of Anesthesia Practice program, I invite you to participate in a research project by taking a few minutes to complete the following survey ([click here](#) for the survey).

The project is titled, "Intravenous Fluid Bolus Prior to Initiation of Epidural Analgesia in Severely Preeclamptic Patients." This study will use a cross-sectional survey design to elicit nurse anesthetist opinion about fluid administration and treatment of hypotension in obstetrical patients during labor. This project's goal is to understand the current thinking of nurse anesthetists who practice obstetrical anesthesia regarding hypotension prevention and treatment in preeclamptic parturients receiving epidural analgesia.

The survey consists of approximately 43 questions and should take no more than 13 minutes to complete. Your participation will provide valuable information. To protect participant privacy, all responses are anonymous. You are not required to answer every question. Answering one or more survey questions implies your consent to participate in this project.

The IRB Project Coordinator can be reached at the University of Michigan-Flint Office of Research at 810-762-3383 or by email at research@umflint.edu. For specific questions pertaining to the survey/project, please contact primary researcher Bradley Stelflug at 812-243-7994 or bstelflu@umflint.edu.

Thank you for your anticipated participation,

Brad Stelflug CRNA, MSN, FAAPM

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Appendix E: Informed Consent

As a graduate student in the University of Michigan-Flint, Doctor of Anesthesia Practice program, I invite you to participate in a research project by taking a few minutes to complete the following survey.

The project is titled, “Intravenous Fluid Bolus Prior to Initiation of Epidural Analgesia in Severely Preeclamptic Patients.” This study will use a cross-sectional survey design to elicit nurse anesthetist opinion about fluid administration and treatment of hypotension in obstetrical patients during labor. This project’s goal is to understand the current thinking of nurse anesthetists who practice obstetrical anesthesia regarding hypotension prevention and treatment in preeclamptic parturients receiving epidural analgesia.

The survey consists of approximately 43 questions and should take no more than 13 minutes to complete. Your participation will provide valuable information. To protect participant privacy, all responses are anonymous. You are not required to answer every question. Answering one or more survey questions implies your consent to participate in this project.

The IRB Project Coordinator can be reached at the University of Michigan-Flint Office of Research at 810-762-3383 or by email at research@umflint.edu. For specific questions pertaining to the survey/project, please contact primary researcher Bradley Stelflug at 812-243-7994 or bstelflu@umflint.edu.

Thank you for your anticipated participation,
Brad Stelflug CRNA, MSN, FAAPM
bstelflu@umflint.edu
812-243-7994

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Appendix F: Normotensive Parturients**Table 6.** Recommendations of fluid bolus for a normotensive parturient

Do you recommend anesthesia providers give an IV fluid bolus prior to labor epidural placement in normotensive parturients? (69 respondents)	Yes	54 (78.26%)
	No	5 (7.25%)
	Maybe, it depends on certain factors.	10 (14.49%)
Factors that influence decision to administer IV fluid bolus in normotensive parturients (Those who responded Maybe, 10 respondents)	NPO status/ Fluid Status	4 (40%)
	Blood Pressure	3 (30%)
	Co-morbidities	1 (10%)
	Department or facility guidelines	1 (10%)
	Epidural bolus dose	1 (10%)
	General health	1 (10%)
	Heart Rate	1 (10%)
	Obesity	1 (10%)
	No response	2 (20%)
Type of Fluid recommended Those who responded Yes	Crystalloid	54 (100%)
	Colloid	0 (0%)
Those who responded Maybe	Crystalloid	10 (100%)
	Colloid	0 (0%)

Note: 69 respondents

Table 7. Recommended amounts of fluid bolus for a normotensive parturient

	Mean Minimum	SD	Mean Maximum	SD
Those who responded Yes	709.20 ml	254.27 ml	882.67 ml	290.57 ml
Those who responded Maybe	650.00 ml	229.13 ml	700.00 ml	244.95 ml
Both sets of respondents	699.17 ml	251.17 ml	851.71 ml	291.52 ml

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Appendix G: Preeclamptic Parturients**Table 8.** Recommendations of fluid bolus for a preeclamptic parturient

Do you recommend anesthesia providers give an IV fluid bolus prior to labor epidural placement in preeclamptic parturients? (67 respondents)	Yes	33 (49.25%)
	No	4 (5.97%)
	Maybe, it depends on certain factors.	30 (44.78%)
Factors that influence decision to administer IV fluid bolus in preeclamptic parturients (Those who responded Maybe, 30 respondents)	Blood pressure	10 (33.33%)
	Fluid status	6 (20.00%)
	Patient's status/current symptoms	5 (16.67%)
	Renal function	4 (13.33%)
	Respiratory function	2 (6.67%)
	Cardiac function	1 (3.33%)
	Edematous status	1 (3.33%)
	Epidural method	1 (3.33%)
	Fetal status	1 (3.33%)
	Headache	1 (3.33%)
	Heart Rate	1 (3.33%)
	Medications	1 (3.33%)
	Multiple factors	1 (3.33%)
	Obesity	1 (3.33%)
Vital signs	1 (3.33%)	
No response	9 (30.00%)	
Those who responded Yes (Type of fluid)	Crystalloid	33 (100%)
	Colloid	0 (0%)
Those who responded Maybe (Type of fluid)	Crystalloid	26 (86.67%)
	Colloid	0 (0%)
	Did not indicate	4 (13.33%)

Note: 67 respondents

Table 9. Recommended amounts of fluid bolus for a preeclamptic parturient

	Mean Minimum	SD	Mean Maximum	SD
Those who responded Yes (33 respondents)	556.25 ml	283.05 ml	671.88 ml	308.96 ml
Those who responded Maybe	302.63 ml	208.68 ml	489.47 ml	219.80 ml

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(30 respondents)

Both sets of respondents	461.76 ml	285.05 ml	603.92 ml	292.70 ml
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Appendix H: Severely Preeclamptic Parturients**Table 10.** Recommendations of fluid bolus for a severely preeclamptic parturient

Do you recommend anesthesia providers give an IV fluid bolus prior to labor epidural placement in severely preeclamptic parturients? (61 respondents)	Yes	18 (29.51%)
	No	10 (16.39%)
	Maybe, it depends on certain factors.	33 (54.10%)
Factors that influence decision to administer IV fluid bolus in severely preeclamptic parturients (Those who responded Maybe, 33 respondents)	Blood pressure	12 (36.36%)
	Fluid status	8 (24.24%)
	Patient's status/current symptoms	8 (24.24%)
	Renal function	4 (12.12%)
	Respiratory function	4 (12.12%)
	Co-existing disease	3 (9.09%)
	Lab values	3 (9.09%)
	Medications	3 (9.09%)
	Cerebral function	2 (6.06%)
	Heart Rate	2 (6.06%)
	Vital signs	2 (6.06%)
	Cardiac function	1 (3.03%)
	Edematous status	1 (3.03%)
	Epidural method	1 (3.03%)
	Fetal status	1 (3.03%)
	Multiple factors	1 (3.03%)
Obesity	1 (3.03%)	
Organ impairment	1 (3.03%)	
No response	5 (15.15%)	
Those who responded Yes (Type of fluid)	Crystalloid	18 (100%)
	Colloid	0 (0%)
Those who responded Maybe (Type of fluid)	Crystalloid	32 (96.97%)
	Colloid	1 (3.03%)

Note: 61 respondents

Table 11. Recommended amounts of fluid bolus for a severely preeclamptic parturient

	Mean Minimum	SD	Mean Maximum	SD
Those who responded Yes (18 respondents)	655.56 ml	398.22 ml	736.11 ml	395.04 ml

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Those who responded Maybe and crystalloid (32 respondents)	346.00 ml	189.69 ml	500.00 ml	158.75 ml
Those who responded Maybe and colloid (1 respondent)	250.00 ml		250.00 ml	
All sets of respondents	475.58 ml	332.60 ml	598.84 ml	305.85 ml

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Appendix I: Teachers/lecturers on high-risk OB anesthesia**Table 12.** Answers from respondents who teach or lecture on high-risk OB anesthesia

What type and volume of IV fluid do you instruct students to administer prior to placing a labor epidural in non-preeclamptic parturients?	<ul style="list-style-type: none"> • 500ml prior to epidurals remained 500ml during procedure • LR 500-1000ml • 1000 • 1000
What type and volume of IV fluid do you instruct students to administer prior to placing a labor epidural in preeclamptic parturients?	<ul style="list-style-type: none"> • Figure fluid volume for patient weight minus what she had taken that day and Pt half the amount determine before epidural • LR 500-1000ml • 500 • 500
What type and volume of IV fluid do you instruct students to administer prior to placing a labor epidural in severely preclamptic parturients?	<ul style="list-style-type: none"> • LR 500-1000ml • 500 • 250

Note: One respondent did not answer question about the severely preeclamptic parturient.

Table 13. Answers from respondents who teach or lecture on high-risk OB anesthesia

What do you teach anesthesia providers to use to treat hypotension in non-preeclamptic parturients? (choose all that apply)	Crystalloid	4 / 100%
	Colloid	1 / 25%
	Ephedrine	4 / 100%
	Phenylephrine	4 / 100%
	Other recommendation	0 / 0%
What do you teach anesthesia providers to use to treat hypotension in preeclamptic parturients?	Crystalloid	4 / 100%
	Colloid	0 / 0%
	Ephedrine	4 / 100%
	Phenylephrine	3 / 75%

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(choose all that apply)	Other recommendation	0 / 0%
What do you teach anesthesia providers to use to treat hypotension in severely preeclamptic parturients? (choose all that apply)	Crystalloid	3 / 100%
	Colloid	1 / 33.3%
	Ephedrine	3 / 100%
	Phenylephrine	3 / 100%
	Other recommendation	0 / 0%

Note: One respondent did not answer question about the severely preeclamptic parturient.

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