HELLP syndrome (hemolysis, elevated liver enzymes, and low platelets) pathophysiology and anesthetic considerations

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HELLP syndrome in the parturient (hemolysis, elevated liver enzymes, and low platelet count) is associated with poor maternal and fetal outcomes. Maternal mortality has been estimated to be as high as 24%. Patients with HELLP syndrome are also at greater risk of pulmonary edema, adult respiratory distress syndrome, abruptio placentae, disseminated intravascular coagulation, ruptured liver hematomas, and acute renal failure. Perinatal mortality is equally high, ranging from 79 to 367 per 1,000 live births, and neonatal complications correlate with the severity of maternal disease.

Many clinicians view HELLP syndrome as an entity of preeclampsia, and because of varied symptomatology, the initial diagnosis may be obscured. Prodromal signs include: (1) weakness and fatigue, (2) nausea and vomiting, (3) right upper quadrant and/or epigastric pain, (4) headache, (5) changes in vision, (6) increased tendency to bleed from minor trauma, (7) jaundice, (8) diarrhea, and (9) shoulder or neck pain.

Before delivery, aggressive obstetric management is directed toward stabilization of the affected organ systems, if possible, and timely interruption of the pregnancy in the early phase of the accelerated disease progression. Definitive therapy is delivery.

Parturients with HELLP syndrome are often critically ill; their infants are frequently premature and their conditions are compromised. Management criteria should include a multidisciplinary approach in a tertiary care center. Obstetric anesthesia personnel should perform a thorough preanesthetic evaluation and be familiar with the pathophysiologic changes of this syndrome. Determining the anesthetic of choice depends on the patient's condition, fetal well-being, and the urgency of the situation. In the presence of severe coagulopathy, regional anesthesia is contraindicated.

Key words: HELLP syndrome, obstetric anesthesia, pathophysiology.

Introduction
In 1982, Weinstein introduced the acronym HELLP to describe symptomatology consisting of hemolysis, elevated liver enzymes, and low platelet count that affected some women with preeclampsia (Figure 1).1 Many clinical investigators view HELLP syndrome as a variant of severe preeclampsia (Figure 2). Preeclampsia, which is a variant of pregnancy-induced hypertension (PIH), is associated with at least two of the three classic clinical features: (1) hypertension, (2) proteinuria, and (3) generalized edema.2
In 1954, Pritchard et al. first described the triad of hemolysis, elevated liver enzymes, and low platelet count in three patients with eclampsia. Since then, similar cases associated with PIH have been reported. It was nearly 30 years later that Weinstein coined the term 'HELLP' to describe this syndrome. Although Weinstein considered HELLP syndrome a unique variant of PIH, others question its existence. Greer and colleagues propose that HELLP syndrome is, in fact, PIH with mild disseminated intravascular coagulation and further suggest that more sensitive laboratory tests should identify an associated coagulopathy. Mar-
prostacyclin 3, 4 have been cited as causative factors. More recently, investigations of nitric oxide synthesis in gravid rats and parturients have produced similar aberrations of this syndrome. 15-17

Overall, a generalized capillary leak causes a fluid shift into the extracellular space. The decrease in colloid oncotic pressure, hypovolemia, hemoconcentration, and increased blood viscosity develops secondary to the accompanying loss of albumin. 18

In HELLP syndrome, striking hepatic changes occur. 19,20 Hepatic blood flow is obstructed when fibrin deposits develop in the hepatic sinusoids. The liver becomes swollen and engorged, stretching Glisson's capsule and producing epigastric or right upper quadrant pain and tenderness. Hemorrhagic periportal necrosis, subcapsular hemorrhage, and in severe cases, spontaneous hepatic rupture may occur. The liver enzymes become elevated and the serum glutamic-oxaloacetic transaminase value can be 700 U/mL or more. Infrequently, acute hepatic failure and jaundice occur. 19,20 Maternal hypoglycemia is a particularly grave laboratory finding; however, the cause of the hypoglycemia is yet obscure, even though it is obviously related to liver failure. 19,20

The hemolysis associated with HELLP syndrome is consistent with a microangiopathic hemolytic anemia. 18,21 Vascular endothelial damage with fibrin deposition results in fragmentation of red blood cells. The peripheral blood smear reveals crenated and distorted red cells with spiny projections along the borders (Burr cells). 21 Also present are schistocytes, which are small, irregularly shaped red cell fragments. The low platelet count associated with HELLP syndrome appears to be due to increased peripheral vascular destruction. Bone marrow studies reveal an increase in megakaryocytes that suggests rapid platelet turnover. In addition, recent studies suggest associated platelet activation, as well as platelet dysfunction. 5,18,20-22

Many tertiary care centers are using a helpful adjunct to serial coagulation screens—thromboelastography (TEG) for a global assessment of coagulation. The TEG in normal pregnancy demonstrates the hypercoagulable state but also correlates with the platelet count. In parturients exhibiting clinical signs of HELLP syndrome, the TEG appears to remain normal despite prolonged bleeding times, and it often provides a faster result than do clinical laboratory studies in an emergency situation. 23,24

Review of literature

Sibai et al described their experience with 442 parturients with HELLP syndrome who were treated at their tertiary care center. 20 The authors used the criteria listed in Table I to standardize the diagnosis of HELLP syndrome.

Table I

<table>
<thead>
<tr>
<th>HELLP syndrome was based on the clinical diagnosis of preeclampsia and the following laboratory abnormalities.</th>
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<tbody>
<tr>
<td>a. Characteristic peripheral blood smear</td>
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<tr>
<td>b. Serum lactate dehydrogenase &gt; 600 µg/L (or total bilirubin &gt; 1.2 mg/dL)</td>
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<tr>
<td>c. Serum aspartate aminotransferase &gt; 70 µg/L</td>
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<tr>
<td>d. Platelet count &lt; 100,000/mm³</td>
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<tr>
<td>Routine laboratory evaluation included</td>
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<tr>
<td>a. Serial measurements of liver function tests</td>
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<tr>
<td>b. Complete blood cell count</td>
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<td>c. Coagulation profile</td>
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<tr>
<td>d. Renal function tests</td>
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<tr>
<td>Disseminated intravascular coagulation defined as</td>
</tr>
<tr>
<td>a. Low platelet count (&lt;100,000/mm³)</td>
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<tr>
<td>b. Low fibrinogen (&lt;300 mg/dL)</td>
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<tr>
<td>c. Positive fibrin split products (&gt;40 µg/dL)</td>
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<tr>
<td>d. Prolonged prothrombin time (≥14 seconds)</td>
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<tr>
<td>e. Partial thromboplastin time (≥40 seconds)</td>
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<tr>
<td>Acute renal failure</td>
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<td>Oliguria-anuria in association with severe renal dysfunction (creatinine clearance ≤ 20 mL/min)</td>
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Poor maternal and fetal prognosis is associated with this symptom complex. Maternal mortality ranged from 3.5% to 24%. Other authors also observed that these patients were at greater risk for complications, such as liver rupture, disseminated intravascular coagulation, abruptio placentae, and acute renal failure. 25-27 Perinatal mortality was similarly high, variously reported as 79 to 100 or 367 per 1,000 live births. Death was due to large placental infarcts, abruptio placentae, intrauterine growth retardation, intrauterine asphyxia, and prematurity. 19,28

The neonate was at increased risk for a variety of complications associated with HELLP syndrome that correlate with the severity of maternal disease. 26,29 Thrombocytopenia and leukopenia were frequently diagnosed in neonates (25% to 30%) of mothers with HELLP syndrome. The strong correlation with the severity of maternal disease implies that a humoral mechanism may be involved in the etiology of HELLP syndrome. 26,29

Data, however, were minimal regarding the outcome of subsequent pregnancies and long-term prognosis after the syndrome of hemolysis, ele-
vated liver enzymes, low platelet count, and acute renal failure. Sibai and Ramadan, in a study of 32 parturients with HELLP syndrome, indicated an increased risk for preeclampsia to develop in subsequent pregnancies. However, pregnancy outcome and long-term prognosis were usually favorable in the absence of preexisting chronic hypertension. Risks were significantly increased for both mother and fetus if the parturient had preexisting chronic hypertension. Sibai and Ramadan recommended that parturients with preexisting chronic hypertension who have had HELLP syndrome be counseled regarding the likelihood of severe preeclampsia and poor fetal outcome in subsequent pregnancies.

**Obstetric management**

Definitive therapy for the patient with HELLP is delivery of the placenta. Delivery should be expeditious, as any delay is associated with poor neonatal outcome. Prior to delivery, aggressive control of the manifestations of disease is the goal. Pregnancy is usually allowed to continue as long as no evidence of compromise in the fetal or maternal condition is apparent. Medical management is directed toward stabilization of the cardiovascular system, improvement of intravascular volume, prevention of intracranial hemorrhage, and control of central nervous system irritability. Obstetric management of the patient with HELLP syndrome is less clearly defined. Prediction of ultimate disease severity is difficult because it depends on numerous factors. Timely interruption of the pregnancy (i.e., delivery) is often necessary early in the late phase of the disease to prevent accelerated disease progression. Immediate delivery is therefore indicated in patients with progressive thrombocytopenia, neurologic deterioration, hepatic or renal deterioration, or fetal distress.

Although uterine irritability is frequently present and the cervix is often “ripe” for induction, a significant portion of these patients undergo operative delivery due to fetal distress. In Weinstein's later series of 57 patients with HELLP syndrome, 29% of the multiparas and 79% of the primigravidas underwent cesarean section.

Use of invasive monitoring must be considered according to the following criteria:
1. Hemodynamic alterations can be more effectively controlled.
2. Patients may be critically ill and should be managed as such.
3. The severity of the disease is often not clinically apparent.
4. Many of these patients will undergo operative delivery.

These indications for invasive monitoring are similar to those for patients with severe preeclampsia. The indicated entities include:
1. Unresponsive or refractory hypertension.
2. Pulmonary edema.
3. Persistent arterial oxygen desaturation.
4. Oliguria that is unresponsive to modest fluid loading.

The woman's recovery from HELLP syndrome after delivery depends on the severity of the disease. Platelet counts and serum lactate dehydrogenase concentrations may be useful predictors of severity and recovery. The more severe the expression of the syndrome, the more protracted the recovery.

**Anesthetic considerations**

Magnesium sulfate therapy is administered intravenously to reduce central nervous system irritability and prevent seizures. Other effects of magnesium sulfate therapy include reduced hyperreflexia, reduced acetylcholine transmission at the neuromuscular junction, mild vasodilation, mild sedation, and decreased uterine contractility, all of which enhance uterine blood flow. Magnesium sulfate therapy includes reduced hyperreflexia, reduced acetylcholine transmission at the neuromuscular junction, mild vasodilation, mild sedation, and decreased uterine contractility, all of which enhance uterine blood flow. The parturient should receive a loading dose of magnesium sulfate, 4-6 g intravenously (IV) in a 20% solution, infused over 20 minutes. A therapeutic plasma concentration of 8-8.5 mEq is maintained by a continuous infusion of 1-2 g/hr. A plasma magnesium level in excess of the therapeutic range can ultimately lead to severe skeletal weakness, ventilatory failure, and cardiac arrest.

Therapeutic effects of magnesium sulfate therapy are estimated by serial assessment of deep tendon reflexes. Loss or marked depression of the patellar reflexes is an indication of impending toxic effects of magnesium. It should be kept in mind that magnesium increases the sensitivity to nondepolarizing and depolarizing muscle relaxants and readily crosses the placenta where it may produce respiratory depression, hypotonia, and apnea in the neonate.

Antihypertensive therapy should be considered when the maternal diastolic blood pressure remains over 110 mmHg after administration of magnesium sulfate. This therapy is directed toward minimizing the risk of maternal cerebral hemorrhage and abruptio placentae, while maintaining or improving uteroplacental perfusion. Vasodilator therapy combined with plasma volume expansion will achieve these goals. The drugs that have been most commonly used include hydralazine hydrochloride, trimethaphan camsylate, nitroglycerin, and sodium nitroprusside. Hydralazine is the drug most commonly used antenatally; it pro-
duces an effect within 10-15 minutes and has a relatively short half-life. It can produce tachycardia and elevate cardiac output while increasing renal, hepatic, coronary, and cerebral blood flow. The effect of hydralazine on uterine blood flow depends on the degree of preexisting uterine vasoconstriction. To prevent excessive reduction of the blood pressure and to maintain adequate uterine blood flow, hydralazine should be given in small, incremental doses of 2.5-5.0 mg IV, spaced at least 15 to 20 minutes apart, until the diastolic blood pressure reaches 90 to 100 mmHg or the mean arterial pressure is decreased by 15% to 20%. Continuous infusion of hydralazine is not recommended because it increases the potential for precipitous drops in blood pressure and subsequent compromise of uteroplacental perfusion. Diligent blood pressure monitoring is indicated whenever antihypertensive therapy is used.

Trimethapam, a ganglionic blocking agent, can be particularly useful in hypertensive emergencies when cerebral edema and increased intracranial pressure are of concern, because it does not cause cerebral vasodilation. Trimethapam can prolong the action of succinylcholine chloride because of intrinsic cholinesterase inhibition.

In a hypertensive crisis, a continuous infusion of trimethapam, nitroglycerin, or sodium nitroprusside may be effective. Sodium nitroprusside should be limited to short-term use because of the potential for decreased uterine perfusion and fetal cyanide ion toxicity. Nitroglycerin may be associated with methemoglobinemia. Aggressive therapy by continuous antihypertensive infusion should be accompanied by continuous invasive hemodynamic monitoring, preferably with an indwelling radial artery cannula.

If severe hypertension persists despite vasodilator therapy, small doses of propranolol hydrochloride can be administered. Propranolol can cause fetal bradycardia, so fetal heart rate monitoring should be continuous. Other cardioselective beta-1 blockers seem less likely to affect uterine activity, glucose homeostasis, and respirations than does propranolol. Labetalol hydrochloride, which has both beta- and alpha-blocking properties, has been given orally for long-term treatment of PIH with encouraging results. The intravenous preparation of this agent has been used in the pre-induction setting for short-term control of PIH. In pregnant ewes receiving infusions of norepinephrine bitartrate (to stimulate vasoconstriction of the uterine artery), labetalol administration increased uterine blood flow by 25%, lowered maternal mean arterial pressure by 19%, and did not significantly alter fetal heart rate. Thus, labetalol may be an excellent agent for long-term and acute treatment of PIH. Esmolol hydrochloride holds promise for acute PIH therapy but has not been adequately investigated to recommend its routine use. Calcium channel blockers exert an antihypertensive effect through vascular smooth muscle relaxation, but they may also inhibit uterine contractions.

Nifedipine, a calcium channel blocker, inhibits the influx of extracellular calcium ions into smooth muscle cells through slow channels. Its effects predominate in arterial and arteriolar smooth muscle. Of the calcium channel blockers, nifedipine has the most selective vasodilator properties and the least cardiodepressant effects. Common maternal side effects include facial flushing, headache, and tachycardia. Currently available only in capsules, nifedipine rapidly lowers blood pressure after oral or sublingual administration. After an initial dose of 10 mg sublingually, it may be repeated in 30 minutes and then given in a maintenance dosage of 10 to 20 mg every 9 to 6 hours. Physicians should be aware of an exaggerated response in patients receiving magnesium sulfate.

More recently, labetalol has become widely used for control of hypertension and for attenuation of acute hypertension associated with a rapid-sequence induction of general anesthesia in patients with HELLP whose conditions are severely compromised. It has more rapid onset of action and does not produce the tachycardia, nausea, headache, excessive hypotension, and decreased uterine blood flow that are often associated with hydralazine. Caution, however, must be used in the administration of beta-blocking agents to patients with bronchoconstrictive disorders and compromised myocardial function, because these drugs may cause bronchoconstriction and decreased ventricular function.

The best indicator of adequate uteroplacental perfusion is a fetal heart rate (FHR) within the normal range (120 to 160 beats per minute) and evidence of adequate variability and no late onset FHR decelerations. Inadequate perfusion is reflected by significant ominous changes in the FHR. The rate may accelerate or decelerate, depending on the level and duration of fetal distress, and, ultimately, late decelerations of the FHR and loss of variability will occur.

Fluid management and monitoring
Further treatment of a patient with such a compromised condition involves decisions as to monitoring, fluid management, and type of anesthetic to be administered. Monitoring required for anesthetic management will obviously be deter-
Fluid management and volume expansion are important issues in these cases. It is important to remember that aggressive crystalloid administration in the face of generalized arterial vasospasm, a decreased colloid oncotic pressure, and increased capillary membrane permeability can easily result in pulmonary edema. Joyce et al recommended using CVP measurements during fluid therapy and volume expansion, after demonstrating that diastolic blood pressure had an inverse relationship to the volume of fluid needed to raise CVP values to normal levels (6-8 cm H2O). The most severely ill patients with preeclampsia (with diastolic pressure >110 mmHg) had pretreatment CVP measurements of -1 to -4 cm H2O. Large amounts of crystalloid frequently precipitated postpartum pulmonary edema. Large amounts of colloid could have the same effect. A rational approach to volume expansion might be to follow colloid oncotic pressure (COP) measurements and, when indicated, to give moderate amounts of colloid with limited volumes of crystalloid. Kirshon et al recommended that correction of COP be restricted to cases in which extremely low COP values (<12 mmHg) or an extreme negative COP-to-PCWP gradient are identified. They also concluded that the primary benefit of volume expansion appears to be in the prevention of sudden, profound drops in blood pressure with antihypertensive therapy (or as might be the case with sympathectomy from institution of a major regional block), but also in the prevention of fetal distress during labor.

The role of volume expansion in therapy for preeclampsia or HELLP syndrome must not be confused with the need for volume expansion prior to induction of major regional anesthesia. Recommendations by Cheek and Samuels for the management of severe preeclampsia are to restrict hourly IV fluids in the early stages of management and then to base further requirements for fluid therapy on clinical signs of inadequate perfusion, such as decreased urine output, CVP, or PCWP, or increased SVR and normal cardiac output. Fluid should be restricted in the presence of signs of hypervolemia, such as increased CVP or PCWP and normal SVR or in the presence of decreased cardiac output or impending pulmonary edema. It is important to assure adequate volume prior to vasodilation from drugs or regional block to prevent abrupt, severe decreases in systemic perfusion pressure. Cheek and Samuels do not recommend attempting to increase CVP to 6-8 cm H2O in all patients with preeclampsia before administering regional anesthesia, as this may result in fluid overload. The same authors believe it suffi-

Central venous pressure (CVP) monitoring is useful in guiding fluid and vasodilator therapy and determining the likelihood of congestive heart failure. Some authorities proclaim the need for pulmonary artery (PA) catheterization in all patients with severe preeclampsia or HELLP syndrome, citing low correlation between the parameters. Studies by Cotton et al and others have shown that when the CVP is less than 4 mmHg, the pulmonary catheter wedge pressure (PCWP) will be less than 18 mmHg. In general, only when the CVP begins to rise above 7-8 mmHg is there significant risk of an elevated PCWP in the presence of normal CVP. The initial CVP value and subsequent response to fluid infusion can also help determine the potential need for PA catheterization. The placement of a PA catheter is not without risk, especially in a patient predisposed to coagulopathy and is frequently not feasible in many hospitals' labor units where neither experienced personnel nor proper equipment are available. The PA catheter should probably be reserved for cases in which severe hypertension refractory to conventional antihypertensive therapy, congestive heart failure or pulmonary edema, refractory oliguria, critical cardiac lesions, or superimposed cardiomyopathy is evident.

Oliguria may be due to any of several mechanisms that could require different modes of therapy, but will usually respond to modest fluid challenge and delivery of the fetus. Relative intravascular volume depletion and systemic arteriospasm responds to fluid challenge with hemodynamic improvement and decreased systemic vascular resistance (SVR). Selective renal arteriospasm may require volume expansion along with a decrease in afterload, while decreased renal perfusion due to profound vasospasm and reduced cardiac output may improve with fluid restriction and afterload reduction.
cient to raise a negative CVP to a positive value (2-3 cm H₂O) to avoid hypotension following institution of a major regional anesthetic. When diastolic blood pressure is less than 100 mmHg, usually 1-2 L of isotonic balanced salt solution is required. For patients with severe symptoms—diastolic blood pressure more than 100 mmHg and a CVP of zero or less—Cheek and Samuels recommend using no more than 1 L normal saline solution and 25 to 50 g of 25% salt-poor albumin administered over 30 to 45 minutes prior to induction of regional anesthesia, with a goal of achieving a CVP of 2-3 cm H₂O. Further fluid administration is guided by CVP after initiation of the regional anesthetic. Fresh-frozen plasma can be used in place of albumin for the occasional patient who has a coagulopathy and is destined for cesarean section.

### Anesthetic management of labor and delivery

The choice of anesthetic, particularly major conduction anesthesia, in patients with preeclampsia or HELLP syndrome has been a subject of much debate. **Paravertebral analgesia.** Parenteral drugs for sedation and pain control can be used in labor and delivery, but this is certainly not optimal management. This approach is associated with various complications including inadequate relief from the pain and stress of labor and neonatal depression. In the newborn, inefficient metabolism of drugs may result in respiratory depression with the potential for respiratory acidosis, hypoxia, and increased intracranial pressure. Narcotics also possess antidiuretic properties that can contribute to a decreased glomerular filtration rate, ineffective renal plasma flow, and decreased urine output. The currently available information generally supports the use of epidural analgesia as the anesthetic of choice for labor, vaginal delivery, and cesarean section for most patients with preeclampsia and HELLP syndrome.

**Epidural anesthesia.** Epidural anesthesia has been proven safe and effective in these patients when accompanied by careful correction of intravascular volume status, appropriate positioning to avoid aortocaval compression, adequate blood pressure control prior to epidural blockade (preferably a diastolic pressure <110 mmHg), slowly advanced blockade, and, if necessary, cautious use of small intermittent doses of ephedrine. These patients generally have a more pronounced response to ephedrine than usual.

Benefits of epidural anesthesia include optimal obstetric conditions for labor and delivery, with relief of pain and good maternal relaxation without the need for systemic depressant drugs. Studies have not reliably demonstrated fetal or maternal compromise from well-conducted epidural anesthesia. It leads to decreased levels of circulating catecholamines related to relief from the pain and stress of labor and delivery, while decreasing the incidence of maternal hyperventilation and increasing intervillous and renal blood flow. It also permits the use of low-outlet forces for a controlled delivery and eliminates the potential for an exaggerated reduction in SVR compared with that seen in the absence of epinephrine, secondary to a beta-agonist effect of a small amount of systemically absorbed epinephrine; decreased umbilical blood velocity observed in Doppler studies; and possible exaggerated cardiovascular effects or decreased uterine blood flow after inadvertent intravascular injection. Arguments against its use include the potential for an exaggerated reduction in SVR compared with that seen in the absence of epinephrine, secondary to a beta-agonist effect of a small amount of systemically absorbed epinephrine; decreased umbilical blood velocity observed in Doppler studies; and possible exaggerated cardiovascular effects or decreased uterine blood flow after inadvertent intravascular injection. **Argu-**
ments in favor of its use advocate the necessity of epinephrine to help establish the extravascular position of the epidural catheter and that currently available data do not reliably demonstrate an increased incidence of adverse reaction to epinephrine delivered to the epidural space. Some workers advocate the use of epinephrine in the test dose to rule out an intravascular catheter position, with subsequent avoidance of its use.

For labor and vaginal delivery, epidural analgesia should be instituted early in the course of labor to alleviate the need for parenteral narcotics. A segmental block of T-10 to L-1 should be instituted with small, incremental doses of low-concentration local anesthetic until the patient's condition is stable and the level of blockade is established. A higher and denser block can then be readily obtained to assure adequate anesthesia if an urgent cesarean section becomes necessary. Profound perineal anesthesia can be provided with correct positioning of the patient when vaginal delivery is imminent. Once the desired level of blockade is established, it can be maintained by intermittent injections or, ideally, by continuous infusion. Addition of narcotics to the local anesthetic enhances the analgesic effect of the epidural agent.

Subarachnoid anesthesia/analgesia. Subarachnoid block (saddle block) can be used for imminent delivery in these patients, as long as they have been adequately hydrated and positioned to avoid aortocaval compression and the block level is kept at or below T-10 when possible. Some recommend the addition of a low-dose narcotic (10-25 μg fentanyl) to a low-dose hyperbaric local anesthetic. Disadvantages associated with the subarachnoid block include the potential for more rapid and uncontrolled blood pressure changes and the inability to extend the block once it has been established.

Anesthetic management of cesarean section
- **Nonemergency.** For the patient with HELLP syndrome who is scheduled for a nonemergency cesarean section, epidural anesthesia is usually the method of choice. Subarachnoid block might be a reasonable second choice in patients with mild symptoms and can be used safely with meticulous attention to detail, adequate blood pressure control and diligent monitoring, adequate hydration, proper positioning, and the use of small, intermittent doses of IV ephedrine as necessary. Intrathecal narcotics can also be added to the subarachnoid block for prolonged postoperative pain relief.

- **Emergency with an existing epidural catheter.** For emergency cesarean section when an epidural catheter is already in place, the catheter can be used to provide surgical anesthesia for the cesarean section in most instances. If the epidural catheter is functioning properly at an adequate level and there is not severe fetal distress, the level of epidural anesthesia can generally be extended quickly with a rapid-acting local anesthetic during surgical preparation without delaying the surgery or causing further fetal compromise. For acute emergencies, such as abruptio placenta, uterine rupture, or severe fetal distress with an inadequate or very low block level, it might be unwise to rapidly extend the anesthetic level in large increments due to the potential time delay and cardiovascular changes resulting in further compromise to an already jeopardized fetus. If a general anesthetic is unavoidable, any degree of anesthesia present as a result of epidural administration could help to attenuate the severe hypertensive response often seen in these patients after induction, laryngoscopy, intubation, and surgical stimulation.

- **Emergency without an existing epidural catheter.** For a cesarean section that is truly an emergency, the institution of a major regional anesthetic is contraindicated and a general anesthetic is indicated, although it may be fraught with potential hazards in patients with acute exacerbations of HELLP syndrome. There is a higher incidence of complicated airway management, adverse cardiovascular responses, and altered requirements for and responses to administered drugs. There is a greater risk of aspiration secondary to difficult or failed intubation as a result of airway edema that is often present in patients with severe pre-eclampsia or HELLP syndrome. Diligent examination of the airway is indicated, and an awake intubation must be considered in the patient who appears difficult to intubate or in the presence of hoarseness or stridor. Patients with PIH often have extreme cardiovascular responses with potential hypertensive crisis secondary to induction, laryngoscopy, intubation, surgical stimulation, and emergence from anesthesia. Decreased plasma volume, increased interstitial fluid, hypoproteinemia, altered hepatorenal function, and magnesium sulfate therapy can alter maternal requirements for administered drugs and their effects and disposition.

Prior to induction, the patient should be positioned with left lateral uterine displacement and denitrogenated to help assure continued adequate maternal oxygenation. This should also help to diminish the effects of decreased intervillous blood flow, which has been demonstrated by some investigators to occur after induction with thiopental sodium and succinylcholine followed by endotra-
cheal intubation. When feasible, rapid-acting antihypertensive agents, such as labetalol, sodium nitroprusside, nitroglycerine, or trimethaphan, should be used to decrease the diastolic blood pressure to the range of 100-105 mmHg prior to induction and to minimize the potentially extreme hypertensive responses. If magnesium sulfate therapy is already in use, it should be continued intraoperatively. Antihypertensive drugs should remain available and IV lidocaine and potent short-acting narcotics can also be used to minimize the maternal stress response. Even though it may necessitate neonatal respiratory support and pharmacologic reversal, the use of narcotics may be prudent in an effort to blunt the extreme stress responses and the potentially devastating consequences.

Induction can then be accomplished by rapid-sequence technique with cricoid pressure (Sellick maneuver) using thiotepal and succinylcholine followed by endotracheal intubation. Thiotepal can be used in larger doses (4-6 mg/kg) to help blunt the stress response. If magnesium sulfate is being used, no defasciculant is necessary, and sensitivity to succinylcholine may be increased. Ketamine should be avoided because of its sympathomimetic and epileptogenic activity. Maintenance can be accomplished with nitrous oxide and oxygen, along with low-dose potent inhalation agents and muscle relaxants as needed. Narcotics and benzodiazepines can be given after the embilical cord has been clamped.

The inspired nitrous oxide concentration should be limited until delivery, after which it can be increased. The potent inhalation agent of choice might be isoflurane (up to 0.75% prior to delivery) due to its vasodilating activity. The theoretical considerations of halothane usage in the presence of altered hepatic function and the epileptogenic properties and potential for renal toxicity of ethran in the presence of an altered metabolic state and impaired renal function raise concern about the suitability of these agents. Low doses (1/3 to 2/3 minimum alveolar concentration (MAC) of the potent inhalation agents can help to avoid recall and blunt the response to surgical stimulation and are not associated with decreased uterine contractility, increased uterine bleeding, or neonatal depression. Muscle relaxation can be maintained with succinylcholine by continuous infusion. A neuromuscular blockade monitor should be used to guide the dose because there may be an exaggerated response due to the reduced pseudocholinesterase activity seen in pregnancy and the potentiation by magnesium sulfate. Nondepolarizing neuromuscular blockers may also be used, again with careful monitoring. Antihypertensive drugs should be readily available and used as directed by diligent blood pressure monitoring.

Summary
As has been shown, HELLP syndrome can be an extremely serious and complex multisystem disorder involving much more than just hypertension. Special considerations in obstetric and anesthetic management are necessary. Hopefully, continued investigation and new findings might lead to a better understanding of the etiology and pathophysiologic changes of the syndrome and allow improved capabilities in prevention, diagnosis and treatment, thus minimizing the morbidity and mortality currently associated with this syndrome and its complications.

Women with HELLP syndrome are often critically ill. Their infants are frequently premature with compromised conditions. There is no ideal anesthetic for these patients; however, certain management criteria should be observed. These include early diagnosis, hospitalization in a tertiary care center, and a multidisciplinary approach with active involvement of the obstetric anesthesia care team. The obstetric anesthesia personnel must obtain a thorough preanesthetic evaluation and be knowledgeable about the pathophysiologic changes in the parturient with HELLP syndrome.

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