LEARNER OBJECTIVES

After participating in this activity, the learner will be able to:
1. Identify procedures and system changes for improving outcomes in obstetric hemorrhage;
2. Explain procedures and rationale for intrauterine resuscitation;
3. Identify systems for defining urgency of unscheduled cesarean deliveries (decision to delivery interval); and
4. Explain the rationale for various anesthesia care plans for urgent deliveries.

IMPROVING OUTCOMES IN OBSTETRIC HEMORRHAGE

Postpartum hemorrhage (PPH) is defined as > 500 mL blood loss after a vaginal delivery, and > 1000 mL blood loss after a cesarean delivery. PPH is a leading cause of maternal death, both in first and third world countries. The incidence appears to be increasing. Reviews suggest that many deaths from PPH are preventable. For example, 93% of PPH maternal deaths in the State of North Carolina between 1995 and 1999 were judged preventable. Outcomes may be improved by designing and implementing systems to assist providers in the timely recognition and treatment of PPH.

Ensuring the ready availability of blood products is critical to the resuscitation of the hemorrhaging patient. The American Society of Anesthesiologists 2007 Practice Guidelines for Obstetric Anesthesia recommend that a Type & Screen, or Type & Crossmatch should be based in maternal history and anticipated hemorrhagic complications. Unfortunately, a large number of women who hemorrhage do not have risk factors for PPH. At Northwestern Memorial Hospital in Chicago, IL, we have developed a Blood Bank Specimen protocol. The antibody status of most women is assessed during routine antenatal care. Therefore, parturients who are antibody negative and are at low risk of hemorrhage have a sample sent to the Blood Bank on admission, but the sample is not processed (so-called Draw & Hold). Parturients with a diagnosis that is associated with a high risk of hemorrhage (e.g., placenta accreta) receive a Type & Crossmatch on admission. Women with an intermediate risk receive a Type & Screen (e.g., all intrapartum cesarean deliveries). Women who are known to be antibody positive, or have received Rho(D) immune globulin (Rhogam) during pregnancy, have a high likelihood of a positive antibody screen, and therefore, by protocol, receive a Type & Screen on admission. This allows the Blood Bank to identify the antibody shortly after admission in case blood products are needed to treat PPH.

As a group, parturients are young, healthy, and hypervolemic. They remain asymptomatic until they lose a large amount of blood. Thus, the diagnosis of severe PPH is often delayed, resulting in suboptimal resuscitation. Additionally, studies have shown the providers are poor estimators of blood loss, especially when the blood loss is large (> 1 L). In a study using common materials encountered on a Labor & Delivery Unit (e.g., laparotomy sponge, perineal pad, delivery drape) and simulated blood loss, providers (obstetricians, anesthesiologists and nurses) averaged 38% underestimation of blood loss (Fig. 1). After completing an education module, the underestimation improved to 4%. Unfortunately, blood loss estimation skills had decayed after 9 months, demonstrating that education must be ongoing.

Successful resuscitation of hemorrhaging obstetric patients requires a team approach. Teams work together more efficiently and effectively if roles are defined ahead of time, and protocols are defined such that tasks are completed routinely and automatically. At Northwestern Memorial Hospital we have developed a PPH Protocol that defines roles/tasks for the primary nurse, secondary nurse, obstetrician, and anesthesiologist.
The protocol is in a checklist format and is based in the severity of PPH. Several organizations, including the World Health Organization (http://goo.gl/7yNjn) and the State of California (http://goo.gl/Ujxth) have promoted this type of protocol. An additional component of successful resuscitation of the hemorrhaging patient is a critical (or massive) blood loss protocol. Such a protocol allows the Blood Bank to issue large amounts of blood products quickly.7

Clinicians have questioned whether cell salvage can be safely used in obstetric hemorrhage as there is concern about whether amniotic fluid suctioned off the surgical field will result in an iatrogenic “amniotic fluid embolism.” Several in vitro studies, however, have demonstrated that blood suctioned off the field, washed, and then administered through a leukocyte-reducing filter, is safe to transfuse to a hemorrhaging patient.5 Clinical studies also suggest that cell salvage is a safe option in obstetric hemorrhage.10 Therefore, the use of cell salvage should be considered in the setting of massive obstetric hemorrhage.

INTRAUTERINE RESUSCITATION

Updated guidelines for the interpretation of fetal heart rate (FHR) tracings were published in 2008 (Box 1).11 Category 1 FHR tracings are normal, Category 2 tracings are indeterminate, and Category 3 tracings are abnormal. Normal uterine activity is defined as ≤ 5 contractions in 10 min, averaged over a 30-min window. Tachysystole is defined as > 5 contractions in 10 min, averaged over a 30-min window.

Components of in utero resuscitation include 1) checking maternal blood pressure and treating hypotension, 2) changing in maternal position, 3) IV fluid bolus, 4) discontinuation of exogenous oxytocin infusion, 5) maternal oxygen therapy, and 6) tocolytic drug administration.

Maternal oxygen administration: Fetal oxygen content can be improved by increasing the maternal:fetal pO2 ratio. Using fetal pulse oximetry, investigators have demonstrated that the administration of oxygen to the mother increases fetal oxygen saturation (FSpO2); the lower the baseline FSpO2, the greater the effect of maternal oxygen administration.16,17

IV fluid: Investigators studied the effect of an IV fluid bolus in 42 parturients immediately prior to the initiation of neuraxial analgesia (Fig. 2).16 The infusion of 1-L lactated Ringer’s solution over 20 min resulted in a significant increase in FSpO2 (mean 44.8% to 51.1%). This increase was not observed after the infusion of 500 mL.

Change in maternal position: Investigators also demonstrated that placing women in the left or right lateral compared to supine with a 30° head-up position, resulted in an increase in FSpO2 (supine 37.5% ± 9.3, left lateral 48.3% ± 7.8, right lateral 47.7% ± 9.4; P < 0.03).16

Treatment of uterine tachysystole increases uterine blood flow. The half-life of exogenous oxytocin is about 3 minutes; therefore, discontinuing the oxytocin infusion frequently results in resolution of tachysystole. If not, a tocolytic drug is usually administered. In a RCT of terbutaline (250 μg IV) vs. nitroglycerine (400

Intrapartum fetal bradycardia requires intrauterine resuscitation. Clinicians have noted a temporal association between the initiation of neuraxial labor analgesia and fetal bradycardia. Although the mechanism is unclear, it has been suggested that it is related to the acute decrease in circulating epinephrine levels that occur shortly after the initiation of analgesia.12 Epinephrine, via its β2-adrenergic agonist activity, is a tocolytic, and an acute decrease may be associated with an increase in uterine tone, or even tachysystole. Because the uterus is perfused during uterine diastole, an increase in tone causes a decrease in uteroplacental perfusion, leading to fetal hypoxemia and bradycardia.

The reported incidence of neuraxial analgesia-associated fetal bradycardia is 2% to 30%. For example, in a randomized controlled trial (RCT) of the incidence of fetal bradycardia in epidural vs. combined-spinal epidural (CSE) analgesia, the overall incidence of prolonged fetal heart rate decelerations or bradycardia in the first 15 min was 19% (15/77).13 In contrast, in a prospective study of early vs. late labor initiation of neuraxial analgesia, the incidence of new onset non-reassuring fetal heart rate tracing in the first hour after CSE analgesia was 4.1% (15/362).14 Data are conflicting as to whether the risk of fetal bradycardia is higher after CSE than epidural analgesia. Fortunately, the risk of emergency cesarean delivery does not appear to be increased. In a retrospective study, the incidence of emergency cesarean delivery after CSE analgesia was 1.3% compared to 1.4% after administration of systemic analgesia.15
µg IV), there was no difference in rate of successful intrapartum fetal resuscitation (terbutaline 72%, NTG 64%; 95% CI of difference -9% to 2%).18 Both terbutaline and NTG are used off-label for this indication. Additionally, intravenous (as opposed to subcutaneous) administration of terbutaline is off-label.

**URGENT CESAREAN DELIVERY: DECISION TO DELIVERY INTERVAL**

Traditionally, the expectation from the American College of Obstetricians and Gynecologists and the American Academy of Pediatrics is that an institution providing obstetric care should be able to begin a cesarean delivery within 30 minutes of the decision to perform the delivery.19 A number of both retrospective and prospective studies from many parts of the world have found that this benchmark is hard to meet. Studies report the decision-to-incision interval (DII) or the decision-to-delivery interval (DDI). The proportion of DII < 30 min ranged from 52% to 75%.20–22 Among 13 studies, the proportion of DDI < 30 min ranged from 0% in Nigeria23 to 100% in a small German study;24 the proportion in the other 11 studies ranged from 39% to 76%.22 In a study of 13 academic medical centers in the United States, 98% of emergency cesareans for umbilical cord prolapse, placental abruption or previa with hemorrhage, or uterine rupture resulted in delivery within 30 min, but only 62% were delivered within 30 minutes if the indication of non-reassuring fetal status.25 In a 3-month, year 2000 prospective audit of all deliveries in Wales and England, only 16% of Grade 1 cesarean deliveries (immediate threat to life of woman or fetus) achieved a DDI < 15 min, and 46% < 30 min. Thus, it appears all but impossible, no matter the environment, to routinely achieve a DII or DDI < 30 min for all intrapartum cesarean deliveries.

There are obviously some situations in which time is of the essence. For example, in a study of women with placental abruption and fetal bradycardia, a DDI < 20 min, compared to 20–30 min, resulted in a significantly smaller proportion of neonates with poor outcome (neonatal death or cerebral palsy; odds ratio 0.44 (95% CI 0.22 – 0.86).25 However, for most maternal-fetal dyads, and most indications of intrapartum cesarean delivery, fetal outcome is not related to DDI or DII.26–28 In the 2000 Wales-England audit, the 95% CI of the adjusted odds ratio of 5-min Apgar score < 7 (using DDI < 15 min as the reference) was not greater than one until the DDI exceeded 75 min (aOR 1.7 (95% CI 1.2 to 2.4)).26

Thus, it makes sense to prioritize intrapartum cesarean deliveries by indication. Emergencies should be started as fast as possible (e.g., less than 15-min), while other procedures (e.g., arrest of labor with a Category 1 FHR tracing) can safely wait longer than 30 min, if necessary. Lucas et al.27 presented 10 intrapartum cesarean scenarios to 60 obstetricians and 30 anesthesiologist and asked them to use several different classification methods (e.g., visual analogue scale, suitable anesthetic technique, maximum DDI) to rate the scenarios. Clinical definitions were the most useful. The clinical scale was then applied to 407 actual cesarean cases in 6 hospitals. There was close agreement among the obstetricians and anesthesiologists; the 4-point scale had a weighted kappa of 0.91.

At Northwestern Memorial Hospital, we have developed a 4-category system. The obstetrician must “grade” the cesarean when he or she makes the decision to proceed with an intrapartum cesarean delivery (Box 2). The “grade” is documented in the medical record. It assists the nursing staff and anesthesiologists with prioritizing cases, and is also used as a quality management tool.

**Box 2. Intrapartum cesarean delivery grades at Northwestern Memorial Hospital, Chicago, IL.**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Clinical Status</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 1</td>
<td>Clinical status allows for provider availability and compliance with hospital NPO protocol guidelines. Fetal heart rate status Category 1.</td>
<td>a. Arrest of labor; arrest of descent; active genital herpes with ruptured membranes; planned repeat cesarean with prior classical incision or cavity-entering myomectomy in labor; severe preeclampsia.</td>
</tr>
<tr>
<td>Grade 2</td>
<td>Clinical status allows for provider availability but may not allow for compliance with hospital NPO protocol guidelines. Fetal heart rate status Category 2 or Category 3.</td>
<td>a. Arrest of labor; arrest of descent; planned cesarean delivery of an HIV positive patient in labor.</td>
</tr>
<tr>
<td>Grade 3</td>
<td>Clinical status may allow for provider availability. Maternal or fetal compromise is not immediately life threatening. Fetal heart rate status Category 2 or Category 3.</td>
<td>a. Critical threat to life of the woman or fetus and immediate delivery indicated (e.g., placenta previa, abruptio placenta, uterine rupture); fetal emergencies including prolapsed umbilical cord.</td>
</tr>
</tbody>
</table>

**ANESTHESIA PLANS FOR URGENT DELIVERIES**

The induction of anesthesia for an urgent cesarean delivery must be performed quickly, but safely. Although recent data suggest that the maternal mortality gap between general and neuraxial anesthesia has narrowed in recent years,29 most experts still prefer neuraxial anesthesia if time allows. Many women in labor will have an in situ epidural catheter, and a sensory block from a dilute local anesthetic/opioid solution. Thus, quickly extending labor analgesia to surgical anesthesia is the technique of choice. Several studies have investigated methods to shorten latency for surgical anesthesia.

**Chloroprocaine vs. lidocaine:** A small study compared 3% 2-chloroprocaine with sodium bicarbonate to 1.5% lidocaine with epinephrine 1:200,000 and sodium bicarbonate.29 A T4 sensory level to cold was achieved with a mean (SD) of 3.1 ± 0.3 min for chloroprocaine and 4.4 ± 1.6 min for lidocaine. Both drugs provided satisfactory analgesia. Thus, in a very emergent situation, there may be a clinical advantage to chloroprocaine, especially because the lidocaine solution must be mixed with epinephrine, and it is safer to administer large doses of chloroprocaine quickly.
**Addition of fentanyl:** Studies assessing whether the addition of fentanyl, 75 μg to 100 μg, shortens latency, are inconsistent. Hong et al. compared fentanyl to saline in a RCT in women who received 2% lidocaine with epinephrine 1:200,000 for cesarean delivery. Although there was no statistically significant difference in the onset of a T4 sensory level, the study was likely underpowered to show a difference (fentanyl group median (95% CI): 12.5 min (10.4-14.4), saline 15.0 min (13.5-16.5). However, the quality of analgesia was better in the fentanyl group, and there was less nausea.

In contrast, when fentanyl was added to 0.5% levobupivacaine for cesarean delivery, there was no difference in the onset time or quality of analgesia.

**Addition of sodium bicarbonate:** Alkalization of local anesthetic solutions increases the proportion of molecules in the unionized state, thus increasing movement across cell membranes. The addition of epinephrine (1.2 meq) to 15 mL premixed 2% lidocaine with epinephrine 1:200,000 with fentanyl 75 μg increases the pH from 4.3 to 7.4. The latency to a T6 sensory level to pinprick was shorter with sodium bicarbonate (mean 5.2 ± 1.5 (6-12) min; median (95% CI) 3.5 – 5.5). Similarly, the addition of sodium bicarbonate to 2-chloroprocaine shortened latency (sensory block to cold) (2.7 ± 0.8 min vs 4.2 ± 0.8 min).

**Spinal anesthesia:** Kinsella et al. described a case series in which “rapid sequence” spinal anesthesia was used to induce anesthesia for Category 1 (emergency) cesarean deliveries. Components of the technique include deploying other staff to obtain IV access, no skin infiltration, no opioid (increase bupivacaine dose to 15 mg), one attempt, preoxygenate and prepare for general anesthesia, and start surgical procedure when the sensory level is ≥ T10. Using this technique in 25 patients, three required general anesthesia, and three had breakthrough pain, although no supplementation was necessary.

**REFERENCES**

32. Lam DT, Ngan Kee WD, Khaw KS. Extension of epidural blockade in labour for emergency Caesarean section using 2% lidocaine with epinephrine and fentanyl, with or without alkalinisation. Anaesthesia 2001;56:790-4
