Obstetric Anesthesia CME Program

Module 4

CSA now is offering its second CME program. This program's topic is obstetric anesthesia and consists of four modules. The fourth module appears in this issue of the *Bulletin*. The first, second and third modules were offered in the last three issues of the *Bulletin*.

Mark Rosen, M.D., editor and chair of this program, is professor and vice chair and director of the residency training program at the University of California, San Francisco. He also is professor of obstetrics, gynecology, and reproductive sciences, and director of obstetric anesthesia at UCSF.

Registration: The registration page and test questions for this module are at the end of this article. The 10 questions must be answered and submitted to the CSA in order to receive the CME credit. Your CME certificate will be mailed from the CSA office.

Alternatively, the full text of each module of this CME program, along with references, will be accessible through the CSA Web Site, www.csahq.org, in the Online CME Program section, and as part of the online *CSA Bulletin*. To complete Module 4 online, please read the information pages, read and study the text of the module, complete the self-assessment and the evaluation, and then print your CME certificate. Members will need their usernames and passwords to do the modules online.

Fees: This is a free service for CSA members. Nonmembers will be charged $25 per CME credit hour.

Availability: This module is available from December 31, 2007, until December 31, 2010.

Target Audience: This program is intended for all licensed physicians, including anesthesiologists and residents who have an interest in obstetric anesthesia.

Faculty and Disclosures for Module 4:

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Dr. Rollins discloses that he has no relevant financial relationships with any commercial entities.

CME Sponsor/Accreditation: The California Society of Anesthesiologists is accredited by the Accreditation Council for Continuing Medical Education to sponsor continuing medical education for physicians.

The California Society of Anesthesiologists Educational Programs Division designates this educational activity for a maximum of 1 *AMA PRA Category 1 Credit™*.

Evaluation: An evaluation of Module 4 of this series is offered after the test questions. Please fill in your responses and return them to the CSA office. If you choose to do the self-assessment on the CSA Web Site at **www.csahq.org**, you may complete the evaluation of Module 4 online also.

Objectives: Upon completion of this activity, participants will be able to:

- Describe the process of blood salvage and the steps used to minimize exposure to undesirable salvaged materials associated with obstetrics
- Discuss the risks and benefits of using blood salvage in obstetrics
- Cite current guidelines and recommendations regarding the use of cell salvage in obstetrics

Resources: These materials, including questions, are offered on the CSA Web Site at **www.csahq.org.** Instructions for the *Bulletin* version are on the registration page.

Blood Salvage in Obstetrics

By Mark Rollins, M.D., Ph.D.

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UCSF and has been a faculty member since 2004. Dr. Rollins conducts basic research in tissue oxygen delivery and blood substitutes, and has a clinical focus in obstetric anesthesia.

Introduction

Intraoperative blood salvage (cell saver) is a method of "recycling" a patient's red cells that would otherwise be lost. It is used commonly in many surgical procedures when large blood loss is expected, including certain cardiac, vascular, and orthopedic operations. The technique involves scavenging blood lost during an operation, processing it by filtering, washing and centrifugation, and transfusing the scavenged, autologous blood cells back to the patient. For cesarean deliveries, intraoperative blood salvage was initially avoided owing to fear of amniotic fluid reinfusion and the potential morbidity of an amniotic fluid embolism. Although not needed for routine cesarean deliveries, current available evidence supports the use of cell salvage as a valuable option during intraoperative management of massive obstetrical hemorrhage.

Pregnancy Related Death and Hemorrhage

In the United States from 1991-1997, hemorrhage was the third leading cause of maternal death during live birth (13.4 percent), after embolism (21.4 percent) and hypertensive disorders (19.4 percent).[1] In the United Kingdom's Confidential Enquiry into Maternal and Child Health report, maternal deaths from hemorrhage increased from seven in the three years of 1997-1999 to 17 in the years 2000-2002, with the most recent rate of 8.5 deaths per million maternities.[2,3] A World Health Organization systematic review and analysis of causes of maternal death determined that hemorrhage was by far the leading cause of maternal death in both Africa and Asia.[4] Limited supplies of allogeneic (donor) blood and concerns regarding associated transfusion complications have accenttuated the need for effective methods of blood conservation. In the setting of major obstetrical hemorrhage, the use of intraoperative cell salvage provides a readily available, effective means of recycling red blood cells and reducing transfusion needs.

Overview of Cell Salvage Process

The physics and process of intraoperative red blood cell (RBC) recovery relies on the relative densities of the elements in the lost blood and the centrifugal forces of the rotating salvage processor bowl.[5,6] Blood initially is collected from the field through a dual lumen suction tubing in which anticoagulant (heparin or citrate) is fed to the suction tip and immediately mixed with the shed blood. A vacuum pressure below 150 mmHg is normally used to minimize damage to erythrocytes.[5] Blood is carried by vacuum to a sterile collection reservoir and filtered to remove large clots and debris. During the "fill" cycle, blood is pumped

from the collection reservoir through a central tube to the bottom of the spinning centrifuge bowl. The rotating bowl creates a centrifugal force that moves the blood and irrigation to the outer bowl wall. The denser erythrocytes remain held against the wall while the less dense plasma, irrigation fluid, platelets, and other components are forced to the center and spill from the bowl, out an exit tube, and into a waste bag. Blood continues to be pumped from the reservoir to the spinning bowl until a sensor detects the bowl is almost completely full of red blood cells (RBCs). An isotonic wash solution, commonly normal saline, is introduced into the packed RBCs and carries out remaining unwanted contaminants, anticoagulant, and agglomerates into the waste bag. A wash volume of at least three times the bowl volume is used. Normally, after the "wash" cycle is complete, the packed RBCs are pumped from the bowl to a holding bag. The hematocrit of the returned product is normally 50 percent to 80 percent. After the bowl is emptied, a new "fill" cycle can begin. To prevent accidental administration of air to the patient, a transfer bag is used to hold the RBCs. The washed RBCs are passed through a leukocyte reduction filter as a final step to further reduce unwanted particulates prior to reinfusion in the patient.

Concerns Regarding Cell Salvage in Obstetrics

The main barriers to utilizing cell salvage in obstetrics are the perceived risks of amniotic fluid embolism and Rhesus immunization.

The worldwide incidence of *amniotic fluid embolism* (AFE) is estimated to be between 1:8,000 and 1:83,000 live births. In the United States, a study published in 1999 found a rate of 1:20,646 singleton pregnancies.[7,8] Unfortunately, because the occurrence is so rare, a prospective study examining AFE and cell salvage is not feasible. Clinical features of AFE include hypotension, hypoxia, disseminated intravascular coagulopathy, altered mental status, and eventual maternal collapse, signs that must be differentiated from other more common morbidities of pregnancy and delivery. The exact cause and pathogenesis of AFE remains uncertain, but it is no longer believed to be an embolic disease and is felt instead to be a type of anaphylactoid reaction.[8,9] The diagnosis of AFE is a clinical diagnosis of exclusion. Although in the past it had been believed that aspirating amniotic fluid debris such as fetal squamous cells from the maternal pulmonary circulation was diagnostic, the presence of fetal squames has been demonstrated in asymptomatic pregnant women, and no diagnostic laboratory test for AFE currently exists. A case of AFE with cell saver use has never been documented.[10]

Rhesus immunization from fetal RBC contamination is a real risk, as scavenging and separation process cannot distinguish fetal from maternal RBCs. Any fetal cells scavenged are likely to be reinfused into the maternal circulation. To

prevent undesired immunization of Rhesus negative parturients, additional anti-D immunoglobulin (Rhogam) is required. A study by Catling et al. examined the cell salvage processed blood from 27 elective caesarian sections.[11] The range of fetal RBC contamination was 2-19 ml. If the advised dose of 25 mcg (125 IU) of anti-D immunoglobulin per ml of fetal blood is required, a maximum dose of approximately 500 mcg (2500 IU) might be required in the extreme situation.[11] Consequently, it is recommended that if cell saver blood is reinfused into the maternal circulation, Kleihauer-Betke acid-elution assay should be performed as soon as practical to measure the number of fetal red cells compared with the maternal red cells and ensure appropriate dosing.[10]

Amniotic Fluid: Components after Cell Salvage

Although the exact component(s) of amniotic fluid responsible for the clinical events with AFE are unknown, the ability of cell salvage to remove a variety of substances has been examined. Tissue factor is found in high concentrations in amniotic fluid and is believed to potentially contribute to the DIC and hemodynamic collapse associated with AFE.[12] Bernstein et al. utilized banked packed RBCs contaminated with amniotic fluid and processed in cell saver.[13] The concentration of active tissue factor was reduced to an undetectable level post wash. Waters et al. measured the effectiveness of cell salvage washing and the presence of a leukocyte reduction filter at removing other debris associated with amniotic fluid including lamellar bodies, squamous cells, and bacteria.[14] Although concentrations of squamous cells and bacterial counts in the post wash product were significantly greater than the maternal blood, further purification with a leukocyte reduction filter created a product free of lamellar bodies and squamous cells and reduced bacteria counts to levels indistinguishable from maternal blood. Although the use of washing and a leukocyte reduction filter effectively removes all these contaminants, with the exception of fetal RBCs, it still seems prudent to minimize additional exposure by removing as much amniotic fluid as possible by conventional suction prior to employing the salvage suction.

Cell Salvage Studies

Intraoperative cell salvage has been used safely in over 400 published cases, and countless other unpublished cases.[15-20] However, there is one case report from the Netherlands of a 22-year-old Jehovah's Witness with severe preeclampsia and HELLP who died during the use of a cell saver.[21] The patient was severely ill, with starting Hb of 7.1 g/dL and platelets of 48 X 10^9. During cesarean delivery, about 10 minutes after reinfusion of scavenged and washed—but not filtered—autologous blood, the patient became hypoxic and ultimately suffered a cardiac arrest. A clinical diagnosis of amniotic fluid embolism was made. Given her clinical severity, it remains uncertain if cell

salvage contributed to her death. The fact that no clearly documented case of AFE has occurred with intraoperative cell salvage adds reassurance to the safety of the technique. However, because of the unclear pathogenesis of AFE and its infrequency, a prospective randomized trial of cell saver use in obstetrics is unlikely to ever be completed. Therefore, the exact level of safety or risk cannot be determined, and the technique should be utilized only for cases of massive obstetrical hemorrhage where the benefits far outweigh the likely small, but unknown, risk of complications.

Red Cell Transfusion Risks

Transfusion risks from donor units include infectious, noninfectious, and immunologic. The current infectious risks of HIV and Hepatitis C (HCV) have markedly declined over the past decade and are currently less than 1:2,000,000 after implementation of nationwide nucleic acid-amplification testing of blood donors for HIV and HCV.[22,23] However, other adverse events are more frequent—bacterial infections, primarily from *Yersinia enterocolitica* (1:65,000); transfusion-related acute lung injury (1:5000); and clerical error (1:12,000) continue to account for more frequent adverse events related to blood administration.[24] In addition, there is always the possibility of newly emerging infectious agents that are not yet screened. Intraoperative cell salvage represents an effective method of blood conservation that eliminates the risk of viral transmission or clerical error.

Complications to Cell Salvage

Air embolism is a catastrophic complication that is completely preventable by allowing the washed returned blood to flow from the holding bag to a transfer bag and removing the air from the transfer bag prior to reinfusion. If the cell saver primary reinfusion system is connected directly to the patient, the chance of infusing accumulated air and causing an air embolus is significant. Under no circumstances should any bag of salvaged blood be placed in a pressurized rapid infuser, as unremoved air could be transfused into the patient.

Use of incorrect wash solution is another possible complication. Normally, large three-liter bags of isotonic crystalloid are used. Unfortunately, other large bags of fluid—such as glycerol or sterile water—may be stored in the operating room and mistaken for the intended wash solution. Use of either could result in severe morbidity or death.

Poor processing of salvaged blood can lead to complications of disseminated intravascular coagulation or acute renal failure and has been associated with inadequate centrifuge bowl filling and poorly trained personnel.[25,26]

It is critical to have dedicated, well-trained personnel operating the cell salvage equipment to minimize the chance of potential complications.

Risks vs. Benefits

The benefits of cell salvage include a conservation of allogeneic blood and reduction in transmitted disease exposure. The red cells returned to the patient are of better quality as they have not been stored for an extended period of time. Extended storage is associated with loss of 2-3 DPG. The rate of return or cell salvage efficiency of lost RBCs is approximately 50 percent to 60 percent, and the process becomes more cost-effective with larger blood losses requiring two or more units to be transfused. However, this varies, depending on equipment and personnel contracts.[6,27,28]

The concerns of cell saver use in obstetrics include difficulty in accessing safety and inability to do an appropriate randomized controlled trial due to the infrequency of AFE. The efficacy and cost efficiency are dependent on volume loss and, therefore, cell salvage is not utilized in otherwise uncomplicated cesarean sections where blood loss varies between 500-1000 ml and transfusion of any blood is not normally needed. Although cell saver can be mobilized quickly if certain "stand-by" protocols are in place[29] and trained, dedicated personnel are available, it is most effective if the massive obstetrical hemorrhage is anticipated and appropriate preparation is undertaken.

Opinion Statements from Professional Societies

Over the past few years a variety of professional societies have incorporated into their guidelines the following statements regarding cell salvage and obstetrics.

"In cases of intractable hemorrhage when banked blood is not available or the patient refuses banked blood, intra-operative cell-salvage should be considered if available."

The American Society of Anesthesiologists (ASA),
Practice Guidelines for Obstetric Anesthesia, October 2006

"Cell salvage may be considered in cases of high risk of massive haemorrhage"

Royal College of Obstetricians and Gynaecologists (RCOG),
Guideline No. 27, October 2005—Placenta Praevia and Placenta Accreta

"If the diagnosis or strong suspicion of placenta accreta is formed before delivery…Cell saver technology should be considered if available as well as the appropriate location and timing for delivery…"

American College of Obstetricians and Gynecologists (ACOG), Committee Opinion No. 266, January 2002—Placenta Accreta

Summary

Successful treatment of obstetric hemorrhage requires preparedness, communication, and a multidisciplinary approach. Cell salvage is a proven, effective means of blood conservation. When significant hemorrhage is anticipated, cell salvage should be part of the intraoperative plan if available. Methods to improve safety to the patient include 1) removing as much amniotic fluid by conventional suction prior to employing the salvage suction, 2) use of a leukocyte reduction filter, 3) use of appropriate amounts of anti-D immunoglobulin, and 4) the presence of trained dedicated personnel to operate the cell salvage system.

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Obstetric Anesthesia CME Program

In this issue of the *Bulletin*, Module 4 of the Obstetric Anesthesia CME Program is available. Modules 1 through 4 are now available on the CSA Web Site at **www.csahq.org**. The online module uses a self-assessment so that you can complete the test and evaluation, and then print your CME certificate. You also may contact the CSA office at 800-345-3691, and we will send you the materials by fax or mail.

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11 x 11 = 121

111 x 111 = 12321

1111 x 1111 = 1234321

11111 x 11111 = 123454321

111111 x 111111 = 12345654321

1111111 x 1111111 = 1234567654321

11111111 x 11111111 = 123456787654321

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Registration

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Questions

Only one correct answer for each:

1. In the United States from 1991-1997, which of the following was the most common cause of maternal mortality?
    a. Hemorrhage
    b. Embolism
    c. Infection
    d. Hypertensive disorders

2. During cell salvage processing, separation of red blood cells from other components of the shed blood and irrigation relies on their relative density and what force?
    a. Gravity
    b. Magnetic
    c. Electrical
    d. Centrifugal

3. The diagnosis of amniotic fluid embolism is a clinical diagnosis of exclusion.
    a. True
    b. False

4. Which of the following contaminants of obstetric cell salvage is NOT effectively reduced to maternal circulation levels after washing and passing through a leukocyte reduction filter.
    a. Lamellar bodies (phospholipids)
    b. Fetal squamous cells
    c. Bacteria
    d. Fetal RBCs
    e. Tissue factor

5. Intraoperative cell salvage has been used safely in over 400 published cases.
    a. True
    b. False

6. The current risk of transfusion-related acute lung injury from each unit of donor packed red blood cells is currently estimated to be approximately:
    a. 1 in 100
    b. 1 in 5,000
    c. 1 in 10,000
    d. 1 in 50,000

7. Potential complications from cell salvage include which two of the following?
    a. Clerical error
    b. Air embolism
    c. Incorrect wash solution
    d. Viral transmission

8. Potential benefits of utilizing cell salvage in obstetrical cases of massive hemorrhage include:
    a. Conservation of allogeneic blood
    b. Return of better quality RBC compared to stored blood
    c. Improved cost-effectiveness with larger blood loss
    d. No risk of viral transmission or clerical error with salvaged blood
    e. All of the above

9. All of the following societies have provided a statement addressing the use of cell salvage in obstetrics except:
    a. Royal College of Obstetricians and Gynaecologists (RCOG)
    b. American Society of Anesthesiologists (ASA)
    c. American College of Surgeons (ACS)
    d. American College of Obstetricians and Gynecologists (ACOG)

10. The use of cell salvage in uncomplicated cesarean delivery is cost-effective and beneficial.
    a. True
    b. False

Evaluation of Module 4

As part of the CSA Educational Programs Division's ongoing efforts to offer continuing medical education, the following evaluation of this program is requested. This is a useful tool for the EPD in preparing future CME programs.

1. How well were the learning objectives of this program met?

Very Well	5	Above Average	4
Average	3	Below Average	2
Not Well at All	1		

2. How relevant was the information in this program to your clinical practice?

Very Relevant	5	Above Average	4
Average	3	Below Average	2
Not Relevant	1		

3. How would you rate this program overall?

Excellent	5	Above Average	4
Average	3	Below Average	2
Poor	1		

4. Did you detect any commercial bias in this module? Yes No