SOCIETY OF CARDIOVASCULAR ANESTHESIOLOGISTS
Knowledge • Care • Investigation

Example PBLD from Kelley Watson and Michelle Capdeville from SCA 2007

Table #1 Pregnancy and Cardiopulmonary Bypass

Kelley Watson, M.D.
Assistant Clinical Professor
Department of Anesthesiology
Yale University School of Medicine
New Haven, Connecticut

Michelle Capdeville, M.D.
Associate Professor
Chief, Cardiothoracic Anesthesia
Department of Anesthesiology and Perioperative Medicine
University Hospitals/Case Medical Center
Cleveland, Ohio

OBJECTIVES

At the conclusion of this PBLD, the participant will be able to:

1. Discuss the physiologic change of pregnancy and their implications in the parturient undergoing cardiac surgery
2. Understand the risks to mother and fetus during surgery requiring cardiopulmonary bypass, as well as the vulnerable periods for the fetus
3. Recognize the effects of drugs used during cardiac anesthesia, and their impact on uterine blood flow and fetal well-being
4. Discuss recommended fetal monitoring strategies, along with management of fetal bradycardia
5. Discuss recommended cardiopulmonary bypass perfusion strategies believed by some to potentially lessen risk to the fetus
6. Develop a treatment plan for the gravid patient requiring heart surgery with cardiopulmonary bypass

CASE PRESENTATION

The patient is a 33 year old G4P0020 who presents emergently at 20 weeks' gestation for redo mitral valve replacement (MVR). She is 15 years status post open mitral valve commissurotomy for rheumatic mitral stenosis, and 11 years status post mitral valve replacement with a St. Jude mechanical prosthesis. Since that time she has been maintained on chronic anticoagulant therapy with Coumadin. During the fourth week of pregnancy the Coumadin was changed to subcutaneous heparin with weekly monitoring of aPTT levels and a target value 2.5 times normal. Her presenting symptoms are new onset dyspnea with minimal exertion and orthopnea. Her medical history is also significant for gestational diabetes, acid reflux, and a 10 pack year smoking history. Her two previous pregnancies ended in spontaneous abortions.

Preoperative laboratory data include: Hb 10.2, Hct 30.5%, platelets 290,000, Na + 132, K + 3.9, Cl - 110, HCO3 - 17, BUN 15, Cr 0.6 mg/dL, glucose 290, aPTT 29, PT 12.0, INR 1.05. The electrocardiogram shows sinus tachycardia at 110 beats/min. Preoperative transesophageal echocardiography (TEE) is significant for a mechanical prosthesis in the mitral position with thrombus causing immobilization of one of the leaflets, left atrial enlargement, and normal biventricular function. Estimated PA pressure is 78/42 mmHg. Current medications include heparin 12,000 units SQ bid, folate 2 mg po bid, and a daily prenatal vitamin.

QUESTIONS

1. When the patient asks you what the chances are for survival of her and her baby, how do you respond?
2. What is your plan for monitoring fetal well-being in the perioperative period, and how is this affected by gestational age?
3. How will you proceed with anesthetic induction and maintenance? Will you avoid specific anesthetic or vasoactive medications?
4. Are antifibrinolytic agents appropriate is this patient population, where relative hypercoagulability of pregnancy is a concern? Will the fact that this a third time repeat sternotomy affect your decision?
5. During your discussion with the surgeon and perfusionist, what recommendations can you make regarding the conduct of cardiopulmonary bypass (i.e. temperature, flow, acid-base management, etc.) based on the existing scientific data?

CASE CONTINUATION

The patient was premedicated with famotidine 20 mg po, sodium citrate 20 cc po, and brought to the operating room. She was placed in the supine position with left uterine displacement. Pre-induction monitors included the standard ASA 7 monitors and a radial arterial line. Initial vital signs included BP 100/62 mmHg, HR 110 bpm, and SpO2 92% on room air.

Versed 2mg I.V. Was given in the operating room during monitor placement. A modified rapid sequence induction was carried out with etomidate 20 mg, sufentanil 50 mcg in divided doses, and succinylcholine 100 mg. The patient remained stable throughout induction and the airway was easily secured with a 7.0 ETT. A pulmonary artery catheter and TEE probe were then placed. Initial PA pressures were 73/45 mmHg. The intraoperative TEE exam confirmed the preoperative findings of a thrombosed MVR. The mean gradient across the prosthesis was 15 mmHg. Fetal heart rate monitoring and tocodynamometry were used, and an obstetric nurse was in attendance for the duration of the case. Full Hammersmith dose aprotinin was administered following a negative 1 cc test dose. Anesthetic maintenance consisted of sufentanil, sevoflurane (1% expired concentration or less), and FiO2 100%. Pancuronium was used for muscle relaxation. Prior to sternotomy, the right axillary artery and right femoral vein were exposed and cannulated following heparinization in anticipation of possible dense adhesions.

QUESTIONS

1. Is Versed absolutely contraindicated in pregnancy? What other alternatives are available?
2. In light of the current controversy over aprotinin, are you concerned about its use in pregnancy?
3. What is meant by hypercoagulability of pregnancy?
4. What are the implications of reoperative surgery in this patient?
5. If uterine activity is detected during the surgical procedure, what measures should be taken?

CASE CONTINUATION

The sternum was opened uneventfully and cardiopulmonary bypass initiated following dissection of adhesions around the heart. The patient was then cooled to a core temperature of 28 degrees Centigrade. Following aortic cross-clamping and the administration of cold blood cardioplegia, the mitral valve prosthesis was exposed via a left atriotomy. One leaflet of the prosthesis was immobilized by thrombus and significant pannus ingrowth was noted. The valve was excised and a #25 mosaic bioprosthetic valve was placed in the mitral position. The duration of cardiopulmonary bypass was 3 hours, and the cross-clamp time was 135 minutes.

QUESTIONS

1. What are the advantages of moderate hypothermia during cardiopulmonary bypass? Are there any disadvantages?
2. What are optimal flows and mean arterial pressures in this patient versus the non-parturient?
3. How do temperature and pump flow affect uterine blood flow?
4. How does temperature affect fetal heart rate? Is this important?

5. Are you concerned about awareness under anesthesia in this patient population?

CASE CONTINUATION

Following rewarming and aortic unclamping the heart is deaired under TEE guidance. The valve prosthesis appears to be functioning normally with no perivalvular leaks. As the heart is allowed to fill, the left ventricle appears sluggish, the posterior wall is dyskinetic and the right ventricle is contracting poorly. Air is noted in the left ventricle. It is assumed that air has entered the right coronary artery and the systemic pressure is increased to a MAP 90 mmHg. An epinephrine infusion is then started at 0.05 mcg/kg/min and the patient is successfully weaned from cardiopulmonary bypass.

QUESTIONS

1. Are there any concerns, theoretical or otherwise about the use of inotropes in the pregnant patient?
2. Can vasopressors be used safely in the pregnant population?
3. What should the target hematocrit be in this type of patient?
4. How long should fetal monitoring be continued postoperatively?
5. What are potential effects of maternal mechanical ventilation on the fetus and uterine perfusion?

DISCUSSION

Approximately 4% of parturients in the United States have concomitant cardiac disease, with rheumatic mitral stenosis being the most common condition. The first choice of treatment in the pregnant cardiac patient is conservative pharmacologic therapy. Despite maximal medical management, however, some of these patients will require surgical intervention with cardiopulmonary bypass prior to delivery. The acceleration of symptoms in most cardiac patients during pregnancy is due to the changes in maternal physiology that overwhelm the parturient's compensatory capacity.

The physiologic effects of pregnancy on maternal hemodynamics are well-documented. Changes in the maternal circulation begin in the first trimester with a 3% increase in uterine blood flow. This increase progresses throughout gestation, and by the third trimester, 10-15% of the maternal cardiac output supports the gravid uterus. Along with the increased uterine blood flow, the intravascular volume increases by 35-50%. Physiologic dilutional anemia results from increased plasma volume with no concurrent change in red cell mass. The increase in plasma volume is due to the combined effects of estrogen and progesterone levels on antidiuretic hormone and aldosterone, via the renin-angiotensin system. This interaction promotes sodium retention and fluid accumulation. The increase in circulating prostaglandins and prostacyclin leads to vasodilatation, fluid retention, and normal to slightly reduced blood pressure despite increased intravascular volume.

Other changes in maternal cardiac physiology include a 10-20% increase in heart rate, and a 40-50% increase in cardiac output. The greatest rate of increase in cardiac output occurs in the first trimester, peaking around the 28th week. Early on, most of the increase in cardiac output is due to an increase in stroke volume resulting from the increased intravascular volume. As the pregnancy progresses, the additional increase in cardiac output results from the associated increase in heart rate. This increased demand on the heart is the most likely reason for decompensation in pregnant patients with valvular heart disease. This holds particularly true with stenotic lesions and pulmonary hypertension.

Overall maternal mortality from cardiac disease in pregnancy can be stratified based on functional status early in the pregnancy, and type of cardiac pathology.

The most common indications for surgical intervention during pregnancy are: mitral stenosis, congenital aortic stenosis, prosthetic valve dysfunction, and endocarditis. Maternal mortality is similar to that of the nonpregnant female at approximately 1.5-5%. Fetal mortality remains significantly higher at 16-33%, with an average of 19% over the past 25 years, and no correlation to gestational age. If surgery is delayed until after delivery, maternal mortality can be as high as 14%, depending on the type of cardiac pathology. In both native and prosthetic valve cases, if the surgery is emergent, the maternal mortality rises to 9% compared to 6% for non-emerging cases.

Optimal timing for cardiac surgery in the parturient in terms of fetal outcome is late in the second trimester or early in the third trimester, before the 30th week of gestation. This avoids the period of organogenesis in the first trimester, and the increased cardiovascular demand of the third trimester. Neonatal outcomes do not appear to correlate with gestational age at the time of surgery, duration of CPB, or temperature management.

Anesthetic management during cardiac surgery and selection of pharmacologic agents has always been a source of debate for anesthesia providers. There is a paucity of data supporting one drug regimen over another, with most recommendations based on case reports in the literature. Presently, there is no evidence of teratogenicity with the use of barbiturates, volatile agents, or neuromuscular blockers. There is, however, evidence of growth retardation and an increased incidence of miscarriage with exposure to volatile anesthetics.

Benzodiazepine exposure in the first trimester has long been held to be associated with an increased incidence of cleft lip. Later studies have challenged this belief, indicating no association with oral clefts. As a result of this conflicting data, benzodiazepines are in pregnancy category D, meaning that there is positive evidence of fetal risk, but the benefits may outweigh the risk. Opioids appear to be safe in the parturient, but can cause decreased fetal heart rate and loss of beat-to-beat variability.

Another area of controversy is the use of vasoconstrictors to support blood pressure. Agents with combined alpha and beta effects (i.e. ephedrine) have been considered the ideal vasopressors in pregnancy because they have a minimal impact on uterine blood flow

versus pure alpha agonists. Despite ephedrine's long safety record, studies have confirmed that small doses of phenylephrine (40-100 mcg) are equally safe.

With regard to vasodilators, nitroglycerine has the beneficial effect of causing uterine relaxation with an increase in uterine blood flow. Sodium nitroprusside, on the other hand, does not increase uterine blood flow, and can cause maternal cyanide toxicity at higher doses.

Heparin does not cross the placenta and is a safe anticoagulant in the parturient. Long-term anticoagulation with heparin can in some cases lead to heparin induced thrombocytopenia and antithrombin III deficiency. Protamine, the mainstay of heparin reversal in cardiac surgery, has no specific contraindications in pregnancy, but remains a pregnancy category C medication. Antifibrinolytics such as aminocaproic acid and aprotinin have been used in pregnant patients undergoing cardiac surgery with good outcomes . The theoretical concern that exists is whether the reduction in circulating levels of protein S during pregnancy can lead to a hypercoagulable state compared to the non-pregnant cardiac patient.

Intraoperative monitoring of the fetus during cardiopulmonary bypass procedures has not been done uniformly, and the decision to utilize fetal monitoring should be made in conjunction with the obstetric and cardiac surgical care teams. In the first trimester, confirmation of preoperative and postoperative heart rate is considered adequate by many, since the fetus is not developed enough to survive in the event of premature delivery. When feasible, intraoperative fetal heart rate monitoring and perioperative tocodynamometry are recommended after the 16th week of gestation.

The optimal conduct of cardiopulmonary bypass is controversial, with only anecdotal evidence of "acceptable" practices. While there are no large scale studies to corroborate these "acceptable" practices, there has been a trend toward maintaining higher flows and perfusion pressures during cardiopulmonary bypass. Temperature management is another area of controversy, since virtually every form of temperature management (i.e. normothermia, hypothermia, deep hypothermia with circulatory arrest) has been employed with both successful and unsuccessful fetal outcomes.

The issue of pulsatile flow is also worthy of mention since there is anecdotal evidence that pulsatile flow during cardiopulmonary bypass might reduce uterine contractions and improve placental blood flow via generation of nitric oxide from the vascular endothelium and release of endothelium derived growth factor. Intra-aortic balloon counterpulsation has also been used to generate pulsatile flow on bypass, and presumably improve uterine perfusion.

FURTHER READING

Weiss BM, von Segesser LK, Alon E, et al.: Outcome of cardiovascular surgery and pregnancy: A systematic overview of the period 1984-1996. Am J Obstet Gynecol 1998; 179:1643-1653

Parry AJ, Westaby S: Cardiopulmonary bypass during pregnancy. Ann Thorac Surg 1996; 61:1865-1875

Sutton SW, Duncan MA, Chase VA, et al.: Cardiopulmonary bypass and mitral valve replacement during pregnancy. Perfusion 2005; 20:359-368

Mahli A, Izdes S, Coskun D: Cardiac operations during pregnancy: A review of factors influencing fetal outcome. Ann Thorac Surg 2000; 69:1622-1626

Baraka A, Kawkabani N, Haroun-Bizri S: Hemodynamic deterioration after cardiopulmonary bypass during pregnancy: Resuscitation by postoperative emergency cesarean section. J Cardiothorac Vasc Anesth 2000; 3:314-315

Tripp HF, Stiegel RM, Coyle JP: The use of pulsatile perfusion during aortic valve replacement in pregnancy. Ann Thorac Surg 1999; 67:1169-1171

Willcox TW, Stone P, Milsom FP, Connell H: Cardiopulmonary bypass in pregnancy: Possible new role for the intra-aortic balloon pump. JECT 2005; 37:189-191

Jahangiri M, Clark J, Prefumo F: Cardiac surgery during pregnancy: Pulsatile or nonpulsatile perfusion? J Thorac Cardiovasc Surg 2003; 126:894-895

Vedrinne C, Francois T, Martinot S: Better preservation of endothelial function and decreased activation of the fetal rennin-angiotensin pathway with the use of pulsatile flow during experimental fetal bypass. J Thorac Cardiovasc Surg 2000; 120:770-777

Dolovich LR, Addis A, Vaillancourt JMR, et al.: Benzodiazepine use in pregnancy and major malformations or oral cleft: meta-analysis of cohort and case-control studies. BMJ 1998; 317:839-843

Pomini F, Mercogliano D, Cavalletti C, et al.: Cardiopulmonary bypass in pregnancy. Ann Thorac Surg 1996; 61:259268

Kawkabani N, Kawas N, Baraka A, et al.: Severe fetal bradycardia in a pregnant woman undergoing hypothermic cardiopulmonary bypass. J Cardiothoracic Vasc Anesth 1999; 3:346-349