Cardiopulmonary Bypass During Pregnancy

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Background. **Cardiac surgery during pregnancy carries significant maternal and fetal risk and is typically considered after failure of medical therapy. We sought to determine the maternal and neonatal outcomes of cardiopulmonary bypass during pregnancy.**

Methods. **Twenty-one pregnant patients undergoing cardiothoracic surgery were identified from the Mayo Clinic surgical database (1976 to 2009). Maternal and neonatal outcomes were reviewed.**

Results. **Operations included 8 aortic valve replacements, 6 mitral valve repair-replacements, 2 myxoma excisions, 1 patent foramen ovale closure, 1 myectomy, 2 aortic aneurysm repairs, and 1 prosthetic aortic valve thrombectomy. Median cardiopulmonary bypass time was 53 minutes (range 16 to 185). Twelve patients (57%) required emergent surgery with a median gestational age (GA) of 25 weeks (range 7 to 35.5). Seven patients underwent cesarean section immediately prior to sternotomy delivering viable infants (median GA 31 weeks). In the remaining patients, three additional preterm births occurred, all in operations performed at an early GA (13 to 15 weeks). Median follow-up was 16 months (range 3 to 305). All patients improved to New York Heart Association functional class I or II. One early maternal death occurred 2 days after emergent mechanical aortic valve thrombectomy and 3 late maternal deaths occurred 2, 10, and 19 years postoperatively. Three fetal deaths occurred in mothers with additional medical comorbidities.**

Conclusions. **In the current era, cardiothoracic surgery can be performed with relative safety during pregnancy. Fetal complications (prematurity and death) are associated with urgent, high-risk surgery, maternal comorbidity, and early GA. Emergent surgery appears to confer a higher risk of maternal death.**

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Cardiac disease occurs in 2% to 4% of pregnancies, and if untreated accounts for up to 15% of maternal mortality in addition to conferring an increased risk of both preterm delivery and fetal mortality [1, 2]. In the Western world, congenital heart disease (CHD) accounts for an increasing proportion of cardiac disease encountered in pregnancy. Additionally, as CHD survival rates have improved, the number of women surviving to childbearing age with complex CHD has increased. It is estimated that CHD now comprises up to 50% of cardiac disease in pregnancy [1]. Rheumatic valvular heart disease is the cause of most acquired heart disease seen in pregnancy, with the mitral valve (MV) and aortic valve (AV) most commonly affected [3].

During a normal pregnancy, cardiovascular changes occur to maximize oxygen delivery to the fetus. Cardiac output increases up to 40% above baseline, with concurrent increases in both heart rate and plasma volume. As circulating blood volume increases, red cell mass increases correspondingly but at a lesser rate than the increase in plasma volume, producing a relative physiologic anemia. In addition, there is a drop in both systemic and pulmonary vascular resistances, reducing the blood pressure during the first half of pregnancy [3, 4]. Later in pregnancy, inferior vena cava compression can occur from the gravid uterus, decreasing venous return and eventually cardiac output [5].

While women with heart disease may be in a physiologically compensated state prior to pregnancy, the cardiovascular changes that occur during pregnancy can precipitate a decompensated state relatively unresponsive to medical therapy [3]. In fact, cardiac disease may initially present during a pregnancy. Cardiac surgery during pregnancy has been reported to carry significant maternal and fetal risk and is typically considered only after failure of medical therapy [6]. In this review, we present a summary of the Mayo Clinic experience with cardiopulmonary bypass in pregnancy and subsequent maternal and fetal outcomes.

Material and Methods

A total of 21 pregnant patients undergoing cardiothoracic surgery during the study interval (1976 to 2009) were identified from the Mayo Clinic surgical database. Medical and surgical records were reviewed for operative indications and the details regarding surgical repair. When available, maternal cardiovascular and functional status was determined before and after surgery with

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Abbreviations and Acronyms

AV = aortic valve
CHD = congenital heart disease
CPB = cardiopulmonary bypass
CS = cesarean section
EGA = estimated gestational age
MV = mitral valve
NYHA = New York Heart Association
SGA = small for gestational age
TAA = thoracic aortic aneurysm

echocardiography and clinical reports. Additional data were collected from Mayo Clinic visits immediately prior to surgery and from the most recent visit. Records were reviewed for neonatal outcome and complications. Patients were contacted by phone or mail for further details regarding their obstetrical history, fetal outcomes, and current state of health. Informed consent was obtained for those patients providing follow-up data. Abstracted variables included cardiac diagnosis and prior operations, maternal obstetrical history and pregnancy course, cardiovascular status prior to and after surgery, surgical details, and fetal outcome. The protocol was approved by the Mayo Clinic Institutional Review Board.

Data were expressed as median (range) for continuous variables and as frequencies for nominal or ordinal values. Patients undergoing delivery by cesarean section (CS) at the time of cardiac surgery were included in the cohort. Operations not performed with cardiopulmonary bypass (CPB) were excluded from this series. Emergent surgery was defined by hemodynamic instability needing inotropic support or intubation; patients required hospitalization and immediate surgery. Urgent surgery was defined by symptoms of heart failure and (or) severe symptomatic valve stenosis not responsive to medical therapy; patients required hospitalization and underwent surgery within one week of presentation.

Results

Patient Demographics and Preoperative Data

Details regarding each case, organized by fetal outcome, are summarized in Table 1. Median maternal age was 28 years (range 20 to 40 years). Median gestational age (GA) was 25 weeks (range 7 to 35.5). The etiology of maternal cardiac disease is summarized in Table 2. Congenital heart disease accounted for 48% of maternal cardiac disease, including 7 patients with bicuspid or unicuspid AV.

Seven patients had previous cardiac surgery, and two of these patients had two prior operations. Previous procedures included tetralogy of Fallot repair, partial atrioventricular canal repair, coarctation repair, MV cleft repair, MV replacement, and two patients had AV replacement. The patients with two prior operations included a tetralogy of Fallot repair with subsequent AV replacement and tricuspid valve annuloplasty and the second patient had repair of aortic coarctation with subsequent AV replacement.

Surgical and CPB Information

Operations performed are summarized in Table 1. The median CPB time was 53 minutes (range 16 to 185), median cross-clamp time 35 minutes (range 9 to 128), median flow rate 2.55 $L \cdot min^{-1} \cdot m^{-2}$ (range 2.2 to 2.7), and median perfusate temperature 37°C (range 20 to 37). Twelve patients (57%) required urgent or emergent surgery with seven undergoing CS immediately prior to sternotomy delivering viable infants (median GA 31 weeks) in all cases. Urgent or emergent procedures included two for ruptured thoracic aortic aneurysm, four for MV or AV prosthesis obstruction, five for severe AV stenosis, and one for severe MV stenosis.

During the study period, normothermic, nonpulsatile CPB was performed using a flow rate of greater than 2.4 $L \cdot min^{-1} \cdot m^{-2}$ while maintaining mean arterial pressure greater than 70 mm Hg. If the mean arterial pressure was lower than 70 mm Hg, the initial management was to increase pump flow; vasoconstrictors (phenylephrine or vasopressin) were used sparingly. Prior to initiating CPB, each patient received an initial dose of heparin (3 mg/kg) with a target activated clotting time of 550 seconds, and an additional dose of heparin (0.3 to 0.6 mg/kg) was administered to the patient if the activated clotting time was less than 550 seconds. The initial CPB prime was Plasma-Lyte solution (0.8 to 1.5 L; Baxter Healthcare Corp, Irvine, CA); however, when the anticipated hematocrit on CPB was below 24% (hemoglobin 8 g/dL), red blood cells were added to the prime. Heparin (10,000 units) was also added to the CPB prime. Current practice includes using smaller circuitry to minimize prime volume as well as the use of retrograde arterial or venous autologous priming. Over the 30 years, a variety of CPB pumps and oxygenators were used including, most recently, the Sorin S5 pump (Sorin Group USA, Arvada, CO) and the Terumo-Capiox membrane oxygenator (Terumo, Ann Arbor, MI).

Maternal Obstetric History and Clinical Outcomes

Maternal obstetric history and outcomes are reviewed in Table 3. Approximately half (52%) of the women had a history of prior successful pregnancies while 38% had a past history of miscarriage. Prior to surgery, 62% of women were NYHA (New York Heart Association) class III or IV with improvement to NYHA class I in 90% of women after repair (Table 4). Median length of hospitalization was eight days (5 to 17 days), and median time to follow-up was 16 months (range 3 to 305). There was one early maternal death two days after emergent mechanical AV thrombectomy (1985); a viable infant was delivered by CS prior to cardiac surgery. There were three late maternal deaths (Table 1). One case occurred two years after AV replacement due to endocarditis. The second case occurred ten years postoperatively due to congestive heart failure in a patient with MV stenosis and impaired cardiac function. The last case occurred from thrombosis of a prosthetic MV nineteen years postoperatively. Long-