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CASE REPORTS

Use of Doppler ultrasound in the management of uteroplacental perfusion during cardiopulmonary bypass in pregnancy

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ABSTRACT
Cardiopulmonary bypass, the extreme of non-obstetric surgery during pregnancy, presents unique challenges to minimize maternal and fetal risk. We present our experience with a woman who was diagnosed with a left atrial myxoma following an ischemic cerebrovascular accident. We discuss clinical management specific to cardiopulmonary bypass during pregnancy and delivery in the context of a multidisciplinary team approach. We recommend using intermittent Doppler ultrasound as a non-invasive real-time assessment of uteroplacental perfusion during non-obstetric surgery in pregnancy. Monitoring of perfusion facilitates active feedback for appropriate in utero resuscitation in these cases.
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Introduction

Cardiovascular surgery during pregnancy requiring cardiopulmonary bypass increases the risk of fetal mortality by up to 20%.[1] Fetal morbidity and mortality can be reduced with the use of fetal-maternal Doppler ultrasound as a surrogate for maternal oxygen transportation and uterine blood flow.[2] We present the case of a woman undergoing cardiopulmonary bypass (CPB) during pregnancy where intermittent Doppler ultrasound was used to assess fetal wellbeing during the procedure by monitoring uteroplacental blood flow.

Case report

A previously healthy 28-year-old G4P3 woman presented to a rural emergency department at approximately 26 weeks of gestation with 4 h of amnesia subsequent to headache and visual scotomata. She received treatment for presumed migraine and, when symptoms abated, was discharged with an outpatient referral to neurology. Later consultation uncovered persistent lateral visual field deficits in the left eye. Brain magnetic resonance imaging revealed discrete diffusion abnormalities in the left lateral and right medial caudate nuclei. These findings, suggestive of small microembolic cerebrovascular accidents, prompted further investigation. Transthoracic echocardiography demonstrated a 4 cm mobile intracardiac mass nearly filling the left atrium. One-half of its volume was found to prolapse across the mitral valve annulus during diastole. Biventricular size and function were otherwise normal, without evidence of a septal defect or other valvular abnormality. Thrombophilia testing revealed heterozygosity for the Factor V Leiden mutation (FVL). Anticoagulation was achieved with low-molecular-weight heparin (LMWH) and low-dose aspirin. Multidisciplinary care coordination occurred between perinatology, cardiothoracic surgery, cardiology, anesthesiology, neonatology, the CPB perfusion team, and surgical and obstetric nursing staff. Consensus was reached for surgical resection of the offending mass at 30 weeks of gestation with planned intensive Doppler assessment intraoperatively to guide perfusion management, unless earlier intervention was required.

The patient received betamethasone, in anticipation of iatrogenic premature delivery, to promote fetal lung

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maturity. She was admitted at 29 weeks and six days to bridge from LMWH to intravenous unfractionated heparin. A magnesium sulfate infusion was initiated 12 h before surgery for fetal neuroprophylaxis. Baseline transabdominal Doppler velocimetries of the maternal uterine artery (UA) and fetal umbilical artery (UmbA) were obtained before surgery.

In the immediate preoperative period, the patient was positioned supine with left lateral uterine displacement, and standard anesthesia monitors were placed. Under light midazolam sedation, two large-bore peripheral intravenous catheters and a radial arterial pressure catheter were inserted. General anesthesia was induced by rapid-sequence technique, with a combination of propofol, fentanyl, and succinylcholine. An ultrasound-guided internal jugular introducer was placed, in addition to a Foley catheter. A second Foley urinary catheter was placed intravaginally to permit intraoperative assessment for concealed vaginal bleeding in the event of abruption. A transesophageal echocardiography (TEE) probe was inserted to allow continuous functional assessment of the maternal heart (pre- and post-bypass), as well as to monitor complete de-airing of the heart after completion of the open cardiac repair.

Median sternotomy was used to achieve operative access, and CPB was initiated utilizing a strategy of pulsatile, high-pressure flow (2.0–6.6 L/min/m^2) under normothermic conditions (35.4–37.1°C) with cold blood cardioplegia. The mass was resected en-bloc through a left atrial incision, requiring excision of a small portion of the interatrial septum at the origin of the stalk. Total time on CPB was 79 min, with aortic cross clamp time of 49 min. Mean arterial pressure (MAP) was maintained at 60–80 mmHg (mean 64.6 mmHg). Dilutional anemia (7.2 g/dL, from baseline of 11 g/dL) was anticipated and confirmed after initiation of CPB and was managed with transfusion of one unit of packed red blood cells.

The fetus was continuously monitored with external cardiotocography (EFM). Transabdominal Doppler interrogations of UA and UmbA were obtained to assess uteroplacental perfusion during key surgical and CPB transitions (baseline, initiation of CPB, aortic cross clamp on/off, discontinuation of CPB, and follow-up; Fig. 1). Over the CPB course, a consistent increase in the UA pulsatility index (PI) was observed. After atrial closure, repair of the atrial septum, and removal of air from the heart, the aortic cross clamp was removed with preparations made for transition off CPB. A brief episode of hypotension as measured at the radial artery was encountered secondary to a post-bypass, low systemic vascular resistance state. In response, the patient was placed in the Trendelenberg position post-CPB as a non-pharmacologic intervention to support blood pressure (BP) and cardiac output. However, concomitant with position change and despite rapid normalization of maternal BP, a two-minute spontaneous fetal heart rate deceleration (from a baseline of 145 beats/min to a nadir of 65 beats/min) was observed. In response, the patient was taken out of Trendelenberg and aggressive volume replacement yielded rapid resolution to a reassuring fetal tracing. While the initial hemodynamic change in BP likely led to an initial decrease in uteroplacental perfusion, as evidenced by an increase in the umbilical artery systolic/diastolic (S/D) ratio on Doppler, temporary vasospasm at the uteroplacental interface could account for the continued effect following normalization of BP.

Normal biventricular contractile function was demonstrated with TEE and was utilized for optimization of cardiac filling volumes. Inotropic or pressor support was never required. Notably, the fetal heart rate decelerations coincided with an acute increase in the UmbA S/D ratio, >2 standard deviations (SD) above the mean, with progression ultimately to absence, but not reversal, of end-diastolic flow. Forward diastolic flow returned 30 min after removal of CPB, but modest elevations of the S/D ratio remained evident on follow-up 72 h postoperatively.

Rhythmic uterine contractions were noted during the latter intraoperative portion of the procedure, continuing for approximately eight hours. Tocolysis was initiated at completion of the procedure using a magnesium sulfate infusion and a 48-h course of indomethacin. Postoperatively, the patient was taken to the intensive care unit with successful extubation performed 8 h post procedure. We continued EFM for 48 h, after which the patient was transitioned to routine care and discharged home on postoperative day 5. Final pathology revealed a $5 \times 3 \times 1.8$ cm focally hemorrhagic and calcified, spongy, gelatinous mass consistent with an atrial myxoma (Fig. 2).

The remainder of the patient's prenatal course was uncomplicated. Adjusted-dose LMWH (40 mg twice daily) and low-dose aspirin were maintained until 36 weeks, and spontaneous labor occurred at 40 weeks. Early epidural analgesia provided several benefits, including pain relief to prevent unnecessary increases in cardiac output through reduced sympathetic outflow (heart rate reduced compared to the presence of painful stimuli), and to minimize inadvertent Valsalva efforts from the mother that would place tension on the recent cardiac incision and healing sternotomy. Forceps-assisted vaginal delivery limited excessive increases in cardiac output and resulted in the birth of a 3.63 kg neonate with Apgar scores of 9 and 9, at 1 and 5 minutes, respectively. The postpartum course was uncomplicated, with mother and baby discharged on postpartum day 2. Low-dose aspirin was resumed postpartum.

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