Volume manipulation by phlebotomy for cesarean section in a patient with pulmonary hypertension

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Abstract
Pulmonary hypertension in a parturient is known for its high perioperative mortality. We describe a successful case of cesarean section performed under general anesthesia in a parturient with pulmonary hypertension. A distinctive feature of our management was active blood volume manipulation by phlebotomy and reinfusion of the blood. Just after the baby was delivered, about 250 ml of blood was phlebotomized to counteract autotransfusion by the contracting uterus. We stopped phlebotomy at this volume because moderate systemic hypotension occurred. The blood was slowly infused, with transesophageal echocardiography used to evaluate right ventricle filling. The patient was hemodynamically stable during the operation and had an uneventful postpartum period. Her baby's perioperative course was also uneventful.

Key words Phlebotomy · Cesarean section · Pulmonary hypertension

Introduction

Pulmonary hypertension (PH) in a parturient is associated with high mortality [1]. The optimal mode of delivery and anesthetic method for these patients are yet to be determined. Hemodynamic stability during the perioperative period is always the top priority. We successfully managed a 32-year-old woman with PH who underwent cesarean section under general anesthesia by means of active blood volume control with phlebotomy and retransfusion. These interventions were safely performed with right ventricle filling being evaluated by transesophageal echocardiography. These interventions may be useful options in patients in the same setting.

Case description

A 32-year-old parturient (height 151 cm, weight 49 kg at 29 weeks of pregnancy) was admitted to our hospital at 29 weeks of gestation for delivery. She had been diagnosed with systemic lupus erythematosus (SLE) about 20 years previously and had a history of multiple admissions due to exacerbations of the disease. She presented at 9 weeks' gestation. She had no cardio-respiratory complaints at that time. Transthoracic echocardiography (TTE) examination revealed slight enlargement of the right ventricle and chest X-ray showed increased pulmonary vascular markings. But as the pregnancy progressed, her symptoms became worse. Exertional dyspnea, arthralgia, and erythema developed and rapidly worsened. She was admitted to the hospital to control her symptoms before delivery. Preoperative physical examination revealed moderate hypoxia with peripheral cyanosis. Arterial blood gas showed pH 7.42, Pa_{CO_2} 30.5 mmHg, Pa_{O_2} 106 mmHg (O_2 $2\ell \cdot min^{-1}$ via nasal cannulae). Echocardiographic and X-ray examinations revealed PH (systolic pulmonary artery pressure, approximately 50 mmHg) and lung congestion with right-sided heart enlargement (cardiothoracic ratio, 64%). After admission, she received large doses of steroids (intravenous methylprednisolone 30 mg and dexamethasone 24 mg daily) for alleviation of her symptoms, and supplemental oxygen. On admission she was diagnosed with deep vein thrombosis by ultrasonographic examination of the lower extremities. Then continuous intravenous infusion of heparin (10000 $IU \cdot day^{-1}$) was started. In spite of these treatments, her condition became worse and the fetus was diagnosed with intrauterine growth restriction. Elective cesarean section was indicated, for which general anesthesia was planned because systemic heparinization was required.

Cesarean section was performed at 33 weeks of gestation. The patient was so nervous that we commenced

invasive monitoring after anesthesia induction, excluding an invasive arterial pressure monitor. The right radial artery was cannulated with a 22-gauge catheter. Anesthesia was induced with incremental doses of midazolam (total, 3 mg) and fentanyl (total, 300 μg), followed by vecuronium 6 mg. The trachea was intubated easily with minimum hemodynamic fluctuations. Anesthesia was maintained with 0.6% sevoflurane throughout the operation. Intermittent bolus injections of midazolam and fentanyl were also given under bispectral index monitoring. She was completely free of intraoperative awareness. After the anesthesia was induced, as a precaution, the cardiac surgeons exposed her right femoral artery for emergent percutaneous cardiopulmonary support. The right internal jugular vein was cannulated with an 8.5-Fr sheath introducer through which a pulmonary artery catheter (PAC) was subsequently inserted. The initial PA pressure was 35/20 mmHg. The left internal jugular vein was also cannulated, using the same sheath introducer, for rapid phlebotomy and transfusion. Transesophageal echocardiography (HD11 ultrasound system and S7-2 Omni TEE transducer; Philips Electronics, Amsterdam, The Netherlands) was employed for the intraoperative monitoring of hemodynamics and volume status. From the beginning of the operation, we started continuous infusion of multiple vasodilators to achieve maximal dilatation of the pulmonary vascular bed. Continuous infusions of nitroglycerin ($1 \mu g \cdot kg^{-1} \cdot min^{-1}$), prostaglandin E_1 ($0.02 \mu g \cdot kg^{-1} \cdot min^{-1}$), and milrinone ($0.1 \mu g \cdot kg^{-1} \cdot min^{-1}$) were commenced. We also started a continuous infusion of vasopressin at the rate of 0.5 U·h^{-1}. Local infiltration of lidocaine was added at the site of skin incision. The targets for hemodynamic parameters were as follows: heart rate less than 100 bpm, systolic blood pressure (BP) more than 90 mmHg, systolic pulmonary artery pressure (PAP) less than 35 mmHg, Sv_{O_2} more than 65%). During the operation, she was hemodynamically stable. Surgical blood loss was about 300 ml (including amniotic fluid). Ten milligrams of midazolam and 500 μg of fentanyl were given before delivery. Her baby was delivered in a "depressed state" (Apgar scores of 3 and 5 at 1 and 5 min, respectively). Two hundred and fifty milliliters of blood were removed by phlebotomy just after delivery and transfusion of the autologous blood was started slowly after the delivery. Bloodshedding was stopped because systemic hypotension (systolic arterial [A] BP < 80 mmHg) occurred. During retransfusion, no signs of right ventricular volume overload, i.e., leftward shift or flattening of the interventricular septum in the transgastric short-axis view, or worsened tricuspid regurgitation were observed. The mean PAP also showed no change (approximately 30 mmHg). Intraoperative hemodynamic values were as follows: systolic ABP, 90–120 mmHg; heart rate

(HR), 50–90 bpm; and central venous pressure, 4–8 mmHg. The mean PAP was about 30 mmHg, which was highest at 36 mmHg (just after delivery) and lowest at 24 mmHg (end of surgery) during the operation. She was transferred to the intensive care unit (ICU), sedated, and ventilated. Several hours later, her trachea was extubated, with no cardiopulmonary deterioration. During her stay in the ICU, her hemodynamic variables remained stable and all vasoactive agents except for milrinone were discontinued. Milrinone was continued until the intravenous line was removed on the seventh postoperative day. Her postpartum course was uneventful and her condition recovered to the same level as that before pregnancy. Her baby was extubated on the day after the surgery, and her postoperative course was also uneventful.

Discussion

Pregnancy and labor in a parturient with pulmonary hypertension (PH) is a serious clinical situation and has been labeled a lethal combination [2]. Primary PH is extremely rare (one to two per million in the general population), but secondary disease-related PH is more common. For example, PH is found in 7.5% of all patients with SLE [3]. A high peripartum mortality of 30% is reported in PH parturients [4]. Thus, contraception in these populations is strongly advised. Once these patients become pregnant, early termination should be recommended. If pregnancy is to be continued, early admission to hospital and careful management of the disease is a key to successful delivery [5]. Usually vaginal delivery is preferred, but cesarean delivery may also be chosen depending on maternal and fetal conditions [6]. The anesthetic method for a cesarean section is also controversial. Regardless of the anesthetics used, minimizing intraoperative hemodynamic changes is the goal of anesthetic management in these patients. Recently, regional anesthesia with the administration of small incremental doses of local anesthetics has been preferred [2]. General anesthesia for cesarean section has been avoided because of the sudden hemodynamic changes related to anesthetic induction and tracheal intubation. When general anesthesia is unavoidable, anesthesia with a high-dose opioid is recommended. We selected general anesthesia because our patient was receiving systemic heparin as she had been diagnosed with deep vein thrombosis. The development of pulmonary thromboembolism would have further exacerbated the PH [7]. Also, she was very nervous and had a strong desire for general anesthesia. Though general anesthesia for PH parturients is associated with a high mortality, we managed the patient successfully with a vigorous approach.

We believe that strict volume control was the most important point in the management of our patient. In a normotensive pregnant woman, the blood volume has increased by 40% above the prepregnant level at 20 to 24 weeks of gestation [8]. This provokes overextension of the right ventricle. Increases in cardiac output and oxygen consumption (approximately 50% and 20%, respectively) lead to exacerbation of hypoxia [8]. The PH parturient is vulnerable to the exacerbation of PH and the development of cardiac failure during late pregnancy, and our patient developed dyspnea on exertion and hypoxia in her third trimester. In addition, postpartum uterine contractions induce the autotransfusion of blood (about 500 ml) and the volume-loading effect of this autotransfusion is considered to be the chief mechanism of circulatory collapse in the immediate postpartum period [9]. Our colleagues previously reported unsuccessful anesthetic management in a parturient with PH and blamed autotransfusion for her hemodynamic deterioration [10]. To counteract this type of hemodynamic change, we phlebotomized 250 ml of blood via the internal jugular vein just after the delivery. We decided to phlebotomize this volume in accordance with comprehensive consideration of the ABP value and TEE findings. Excessive volume reduction may lead to a decrease in cardiac preload and hemodynamic collapse. From this point of view, the evaluation of volume status with TEE is indispensable. The shed blood was slowly returned to our patient under the close observation of TEE. This helped to avoid volume overloading of the right ventricle and also helped to minimize the need for homologous transfusion. To the best of our knowledge, there is no previous report of the use of phlebotomy in these circumstances.

We used two different monitors simultaneously to check cardiopulmonary status. A PAC is useful for the continuous tracking of pulmonary artery pressure (PAP). TEE is advantageous in investigating the cause of hemodynamic changes. In our patient, TEE was very useful as an indicator of cardiac volume status. The effectiveness of the simultaneous use of a PAC and TEE is controversial. Because postoperative circulatory collapse occurs frequently and leads to high mortality in the parturient with PH, the use of a PAC as a strong tool for postoperative care would be justified in such patients.

Additionally, the careful titration of vasoactive agents played an important role in maintaining hemodynamic stability in our patient. Most previous reports employed nitroglycerin as first-line therapy. To achieve maximal dilatation of the pulmonary vasculature with minimal side effects, we used a combination of low-dose nitroglycerin, prostaglandin E1, and milrinone. Milrinone and prostaglandin E1 may affect uterine contractions, but the low-dose use of these drugs to avoid lethal deterioration of hemodynamics may be justified. Actually, appropriate uterine contraction was achieved in our patient after delivery of the infant. We did not use oxytocic agents (usually methylergometrine and oxytocin at our institution). Though nitroglycerin has a tocolytic effect, we think this agent is the mainstay of the treatment for PH and is indispensable. If an apparent bleeding tendency is observed, the use of this agent could be avoided. We did not use nitric oxide, a promising agent for the treatment of PH, in our patient. Inhalation therapy with nitric oxide for the treatment of PH is an "off-label" use in Japan. She and her family refused this therapy, so we had to abandon this therapeutic option. The use of vasopressin was the distinctive feature of our drug choice. Vasopressin is known to increase systemic arterial pressure without provoking pulmonary hypertensive crisis [11]. In our patient, we used several drugs concomitantly and at consistent doses throughout the perioperative period. Thus, we could not evaluate the effect of any single vasoactive agent.

In conclusion, we successfully managed a patient with PH under general anesthesia for a cesarean section. We conducted extensive cardiac monitoring, pharmacologically maximal dilation of the pulmonary vasculature, and strict volume management, including phlebotomy. We believe that this treatment should be taken into consideration in patients in a similar setting.

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