ANESTHESIA FOR PATENT DUCTUS ARTERIOSUS LIGATION SURGERY IN ADULT

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ABSTRAK
Patent Ductus Arteriosus (PDA) adalah suatu kondisi jantung bawaan yang terjadi ketika pembuluh darah normal janin yang disebut *ductus arteriosus*, yang menghubungkan arteri pulmonalis dan aorta di dalam rahim, gagal menutup setelah bayi lahir. Laporan kasus ini berfokus pada manajemen anestesi pada pasien PDA dewasa yang menjalani operasi ligasi PDA, kemudian dilakukan teknik *deep hypothermic circulatory arrest* (DHCA) yang tidak terencana karena terjadi ruptur aorta. Seorang wanita berusia 33 tahun, mengalami gejala kelelahan, sesak napas, dan intoleransi latihan yang memburuk sejak pertama kali didiagnosis 12 tahun lalu. Setelah pemeriksaan menyeluruh, pasien didiagnosis dengan PDA *bidirectional shunt*, hipertensi pulmonal dengan *high flow high resistance*, dan tes oksigen reaktif. Prosedur pembedahan pasien meliputi penutupan PDA melalui median sternotomi dengan mesin *cardiopulmonary bypass* (CPB). Anestesi yang digunakan yaitu anestesi berbasis opioid dengan DHCA selama 9 menit. Beberapa faktor yang perlu diperhatikan dalam DHCA yang tidak terencana antara lain: (1) respon, keterampilan, dan kemampuan adaptasi terhadap situasi dari ahli bedah; (2) pembagian waktu yang baik; (3) pemberian es blok di area sekitar kepala pasien; dan (4) pemberian agen-agen farmakologis seperti midazolam, steroid dan manitol untuk menekan laju konsumsi oksigen serebral serta memberikan proteksi serebral pada kondisi ini. CPB dan DGCA yang disertai dengan tindakan neuroprotektif dan pemantauan yang tepat, dapat menjadi metode anestesi yang aman untuk pasien dewasa penderita PDA dan hipertensi pulmonal yang menjalani operasi ligasi PDA.

Kata kunci : *cardiopulmonary bypass, deep hypothermic circulatory arrest, patent ductus arteriosus*

ABSTRACT
Patent Ductus Arteriosus (PDA) is a congenital heart condition that occurs when normal fetal blood vessel called the ductus arteriosus, connecting pulmonary artery and aorta in the womb, fails to close after birth. This case report focuses on the anesthetic management of an adult PDA patient who underwent PDA ligation surgery, followed by an unplanned deep hypothermic circulatory arrest (DHCA) technique due to aortic rupture. A 33-year-old woman presented with worsening symptoms of fatigue, shortness of breath, and exercise intolerance since she was first diagnosed 12 years ago. After a thorough examination, the patient was diagnosed with a bidirectional shunt PDA, pulmonary hypertension (PAH), high flow high resistance, and reactive oxygen test. The patient's surgical procedure included PDA closure via median sternotomy with a cardiopulmonary bypass (CPB) machine. The anesthesia used opioid-based anesthesia with DHCA for 9 minutes. Several factors that need to be considered in unplanned DHCA include: (1) the surgeon's response, skills, and ability to adapt to the situation; (2) good time management; (3) providing ice blocks in the area around the patient's head; and (4) providing pharmacological agents such as midazolam, steroids and mannitol to suppress the rate of cerebral oxygen consumption and provide cerebral protection in this condition. CPB and DHCA, in addition to neuroprotective measures and proper monitoring, can be secure anesthesia method for adult patients with PDA and pulmonary hypertension undergoing PDA ligation surgery.

Keywords *: cardiopulmonary bypass, deep hypothermic circulatory arrest, patent ductus arteriosus*

INTRODUCTION

Patent ductus arteriosus (PDA) is a congenital heart condition that occurs when the normal foetal blood vessel called the ductus arteriosus (DA), which connects the pulmonary artery and aorta in utero, fails to close after birth.(Kritzmire, Boyer, & Singh, 2022) The DA is an important component of fetal circulation, directing cardiac output away from the lungs toward the placenta to sustain systemic oxygenation. The DA is no longer required after birth since the placental circulation is cut off and removed, the pulmonary vascular bed's resistance lowers, and the lungs take over as the primary source of gas exchange and oxygenation. The DA shuts in >90% of term newborns by 48 hours and in 100% by 96 hours of age. In a small number of individual, a PDA will remain open into later childhood and adult life.(Backes et al., 2022).

The incidence of PDA is 1 per 2500-5000 births in full-term babies, 8 per 1000 births in premature babies, and is 9-12% of all congenital heart disease. PDA cases are usually found in children to adults when echocardiography is performed.(Moore & Schneider, 2016). PDA has an incidence of 8% of total adult congenital heart defects (GUCH/Grown-Up Congenital Heart Disease), while in children the prevalence is around 15%.(Dice & Bhatia, 2017; Mughal, Tousif, Alamgir, & Jalal, 2019). The cause of PDA is still not fully clear, but it is suspected that the predisposing factor is rubella infection which can be triggered during pregnancy or premature birth.(Fisher, Moodie, Sterba, & Gill, 2016; Moore & Schneider, 2016). In chronic conditions, PDA will cause increased pulmonary blood flow, arrhythmia, right heart overload and pulmonary hypertension. Blood shunting from left to right will increase the load on the right heart causing dilation of the atrium and right ventricle. The increase in blood volume entering the right ventricle also causes increased blood flow to the lungs (lung overflow).(Mughal et al., 2019).

PDA is uncommon in adults. Longitudinal cohort studies suggest that the incidence of “silent” PDA, those cases discovered by cardiac imaging in the absence of clinical manifestations, approach 1 in 20 births. PDA has the potential to cause complications such as heart failure, kidney dysfunction, and growth and nutritional disorders. PDA is also a risk factor for chronic lung disease (CLD).(Dice & Bhatia, 2017). American Heart Association/American College of Cardiology guidelines emphasize that considerations for ductal closure among older patients be made in the context of evaluation of left-to-right shunting and hemodynamic assessment for PAH.(Stout et al., 2019). Typically, closure through surgery or device placement is performed in children. However, closure becomes more challenging if complications like infective endarteritis, congestive heart failure, pulmonary hypertension, and calcification developed.(Shinde, Basantwani, & Tendolkar, 2016).

Surgical procedures in patients with adult PDA require complicated and complex anesthesia techniques in maintaining other organ systems during surgery. In adult PDA, aortic rupture often occurs as a complication, so this operation requires good collaboration and communication between the surgeon and the anesthesiologist.(Shinde et al., 2016). Thus, we wrote a case report on the management of anesthesia in adult patent ductus arteriosus (PDA) ligation surgery using the unplanned deep hypothermic circulatory arrest (DHCA) technique.

CASE

The patient, a 33-year-old female, presented with symptoms of fatigue, shortness of breath (SoB), and exercise intolerance. She was first diagnosed 12 years ago during an echocardiography examination on her pregnancy. She got oral medication since than but the symptoms have been worsen. Her daily medication was including bisoprolol 5 mg once daily,

furosemide 40 mg once daily, sildenafil 20 mg 3 times a day, and spironolactone 25 mg once daily. The patient is a housewife. She couldn't do household chores without the feeling of SoB. She was able to walk about 500 m without breathlessness. After a thorough evaluation, including cardiac imaging, the patient was diagnosed with a patent ductus arteriosus, high flow high resistance pulmonary arthery hypertention (PAH), and reactive oxygen test. The patient's surgical procedure involved closure of the patent ductus arteriosus via median sternotomy with cardiopulmonary bypass (CPB).

During the preoperative evaluation, physical examination found that the patient was underwight (body weight 29 kg, BMI 12). There was grade 2 systolic murmur, no rhales, ronkhi nor wheezing on her lungs. A chest X-ray showed pulmonary hypertension and cardiomegaly. Transoesophageal echocardiography examination revealed the PDA diameter was 1.3 cm, bidirectional shunt, left atrium and left ventricle dilatation, eccentric left ventricular hypertrophy and right ventricular hypertrophy. Global and segmental systolic function were both good with EF 55%. Grade Il diastolic dysfunction was found, as well as pulmonary hypertension, mild pulmonary and tricuspid regurgitation.

The patient underwent a ductus arteriosis ligation procedure via sternotomy. Anesthesia procedure midazolam 0.05 mg/kgBB, fentanyl 4 mcg/kgBB, rocuronium as a muscle relaxant. Because there was an aortic rupture, DHCA procedure was performed to obtain good exposure of surgery field. The temperature was maintaned at 20^{o}C. the cross-clamping duration was 60 minutes, whether duration of CPB was 140 minutes. During DHCA, methylprednisolone 30 mg/kg, sodium thiopental 20 mg/kg, and ice packs around head and carotid artery were used for brain protection. The patient was weaned from bypass with heart rate of 115/min and blood pressure 110/55 mmHg in normal sinus rhythm, with inotropic support of injection milrinone 0.4 μg/kg/min with good urine output.

Left femoral artery was cannulated and right internal jugular venous catheter was also inserted. Body warmer was used to prevent hypothermia and blood glucose levels were also checked periodicaly to prevent hypoglycemia. Patient was shifted to the intensive care unit and extubated 48 hours postoperatively.

DISCUSSION

The prevalence of adult patients with congenital heart disease (CHD) is on the rise, leading to an increased likelihood of them undergoing cardiac and non-cardiac surgeries. Understanding the complex cardiovascular anatomy and physiology of CHD is essential for addressing the anesthetic implications of the defect. Anticipation of the unique challenges faced by adults with congenital heart disease undergoing surgeries can significantly reduce perioperative risks.(Kwanten, O'Brien, & Anwar, 2019) Large defects that do not close spontaneously may require percutaneous or surgical intervention to prevent further complications such as stroke, dysrhythmias, and pulmonary hypertension.(Dice & Bhatia, 2017; Mughal et al., 2019). Normally, oxygenated blood is carried out from left ventricle into the aorta, but because there is a defect between aorta and pulmonary artery, some oxygen-rich blood re-enters the pulmonary artery (L to R shunt), resulting in increased right heart volume load and excess pulmonary blood circulation. This chronic right heart overload will cause dilation of the right atrium and right ventricle (Shinde et al., 2016). In this patient, a large defect of 1.3 cm was found.

This 33 years old patient has never had any intervention to correct his heart disease. The shunt in this patient was bidirectional. If the right to left shunt is permanent, Eisenmenger syndrome will occur, resulting in cyanosis with varying degrees of heart failure.(Arvanitaki et al., 2022). This patient's clinical condition was in high-risk category for surgical procedures, so more attention is needed to the risk of complications. Pre-operatively, echocardiogram

should be available. Review of ventilator settings, the fraction of inspired oxygen concentration (FiO2), infusions, and vascular access is also very important prior to providing an anesthetic.(Kritzmire et al., 2022)

Adults with CHD may develop pulmonary hypertension for a variety of reasons. Potential etiology includes pulmonary venous hypertension secondary to elevated ventricular end diastolic pressure, elevated pulmonary venous atrial pressure, or pulmonary vein stenosis.(Baum & Souza, 2018) Many patients also continue to have decreased oxygen saturation secondary to residual shunts, poor lung function. and persistent decreased of pulmonary flow.(Kritzmire et al., 2022) Our patient had symptoms that were worsen so that needed a surgery. During hospitalization, the patient got sildanefil 20 mg/8 hours (orally) and beraprost 20 mcg/24 hours (orally) as a management of pulmonary hypertension. In the preoperative period, the patient also received oxygen therapy of 8 liters/minute for 2 hours before surgery with a non-rebreathing mask (NRM). In principle, the management of pulmonary hypertension needs to be known first whether it is pure PAH or the reactive one caused by administration of vasoactive drugs.(Humbert et al., 2022).

In this case, the patient was induced with intravenous fentanyl, midazolam, and rocuronium. opioid-based anesthesia was used to reduce stress response and improves surgical outcomes.(Kwanten et al., 2019) Anesthesia was maintained with oxygen: air, sevoflurane, fentanyl, and rocuronium. Ventilatory management in a PDA ligation is aimed to maintain pulmonary vascular muscle tone. TheFiO2 and PaCO2 was minimizing between 35-40 mmHg, so that blood flow does not tend to the pulmonary circulation.

In addition to arterial lines and central venous catheters, as invasive continous monitoring, the pulmonary artery pressure was measured using a Swan Ganz catheter. At that time, pulmonary pressure was higher than systemic pressure (mPAP 60 mmHg vs MAP 55 mmHg) so that the patient got milrinone from the beginning of the procedure until the postoperative period with a titration dose starting from 0.375 mcg/kgBW/min. Milrinone administration was proven to be useful in reducing pulmonary artery pressure and reducing the incidence of low cardio output syndrome in pulmonary hypertension patients undergoing heart surgery. In addition to medication, surgeons also perform artherial atrial septal defect (ASD) creation procedures as a "way out" when left ventricular dysfunction occurs after defect closure. During PDA exploration, a rupture occurred so that aorta and pulmonary artery repair were performed. Then the deep hypothermic circulatory capture (DHCA) technique was performed. DHCA is a well-known method utilized in certain surgeries where blood flow stops in all blood vessels as the patient's core body temperature is significantly lowered.(Elmistekawy & Rubens, 2011) Repairs of the aortic arch or congenital repairs involving the aortic arch, may require DHCA.(Patel, Augoustides, Pantin, & Cheung, 2018) In some emergency cases, DHCA may be performed unplanned for example to repair laceration in the right ventricle when opening the sternum.(Elmistekawy & Rubens, 2011)·(Ikenga, Sahu, Okwulehie, & Umeh, 2020)

DHCA is essential for cardiac surgeries where standard cannulation of the proximal aorta cannot achieve cerebral perfusion. A systemic decrease in temperature can facilitate the cessation of blood flow, which is called circulatory arrest.(Ikenga et al., 2020; Patel et al., 2018) Circulatory arrest allows the surgeon to operate in a bloodless environment with better visibility since no cannula or clamps are needed.(Ikenga et al., 2020) The duration of DHCA considered as safe is still controversial. A retrospective study showed an increased risk of stroke when the duration of DHCA was longer than 40 minutes. Acceptable duration ranges from 30-40 minutes due to the increased risk of brain injury. Animal studies show significant brain tissue damage if it lasts longer than 45 minutes.(Conolly, Arrowsmith, & Klein, 2010; Patel et al., 2018) At normal temperature (37°C) the duration of cessation of blood circulation is only permitted for 5 minutes. Cerebral metabolism decreases by 6-7% for every 1°C

decrease in temperature from 37°C, which implies that brain cooling results in a reduction in oxygen requirements.(Shinde et al., 2016) So, if body temperature can be lowered to 15°C then the duration is permitted up to 31 minutes. The maximum duration of stopping blood circulation is 40 minutes because of increasing the risk of stroke. Despite its benefit, prolonged can result in a number of problems of coagulopathy, post ischemic hypothermia and cerebral microembolism.(Cao et al., 2020) Profound hypothermia is associated with dysrhythmias due to electrolyte imbalance, increased plasma viscosity and erythrocyte rigidity, metabolic acidosis, hyperglycemia and altered drug distribution and elimination.(Conolly et al., 2010)

When CPB is resumed after a period of DHCA, hypothermic perfusion should be maintained for 10–20 min before start to do a rewarming to reduce the risk of raised intracranial pressure. Once rewarming commences, the gradient between core and peripheral temperatures should be less than 5ºC. Excessively rapid rewarming with perfusion temperatures more than 37ºC may induce cerebral ischaemia secondary to an imbalance between oxygen supply and demand. Similarly, cerebral hyperthermia should be avoided as this may exacerbate neurological injury and increase the risk of adverse neurological outcomes.(Conolly et al., 2010)

In this case, there was an aortic rupture during surgery. DHCA was performed for 9 minutes. It has been suggested that patients can tolerate up to 30 minutes of DHCA without significant neurological dysfunction.[3] Simultaneously, deep hypothermia reduces cerebral metabolism and oxygen consumption, allowing for a longer period to perform surgery during interrupted cerebral perfusion. As the brain is the most vulnerable organ to ischemia, ensuring adequate cerebral protection necessitates protecting other vital organ systems as well. In our situation, the patient's temperature was maintained at 20°C during the entire period of deep hypothermic circulatory arrest. To protect the brain, external cooling was also utilized using cooling blanked and ice-packs around the carotid artery.

CONCLUSION

A 33-year-old female patient with a bidirectional shunt PDA, PAH, and reactive oxygen test, underwent PDA ligation. During procedure, uncontrollable bleeding occured, so it was decided to repair the PDA in a circulatory arrest condition using 18°C temperature that lasted for 9 minutes. Unplanned DHCA needs the surgeon’s proper response, skills, ann good time management. The utilization of CPB and DHCA, in addition to neuroprotective measures and proper monitoring, can be a secure anesthesia method for adult patients with PDA and pulmonary hypertension undergoing PDA ligation surgery.

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