Vol 3 No. 2 October 2023
Solo Journal of Anesthesi, Pain and Critical Care

E-ISSN : 2797-0035
P-ISSN : 2776-1770

CASE REPORT

Anaesthetic Management during Balloon Atrial Septostomy in Transposition of Great Arteries

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Article Info :
Submitted :
18-06-2022
Accepted :
27-05-2023
Published :
31-10-2023
https://doi.org/10.20961/soja.V3i2.62221

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ABSTRACT

Background: Transposition of the great arteries (TGA) is a congenital heart defect that can cause death in 30% of the first week of birth, 50% in the first month, 70% in 6 months, and 90% in the first year, thus requiring immediate corrective action in neonates with rapid early detection. The purpose of this case study is to highlight management considerations in TGA cases in the Balloon Atrial septostomy (BAS) procedure.
Discussion: A 1-day-old newborn girl was brought to Dr. Moewardi General Hospital in February 2022. The patient had a history of cyanosis when she cried and was born with an APGAR score of 6.7.8. The lips were cyanotic on physical examination, with a SpO2 of 77% with a nasal O2 of 2 lpm. The echocardiography results obtained TGA, ASD II, PFO, and PDA. The patient then underwent a BAS procedure. Anesthesia management was performed using ketamine for induction, air bar, O2, and sevoflurane for maintenance of anesthesia. The operation was successful, and postoperative care was carried out. Anesthesia management aims to keep SVR and PVR to a minimum, with a PVR lower than SVR, to prevent desaturation in the patient. A decrease in PVR also can increase pulmonary blood flow, allowing more blood to be mixed and higher oxygen saturation in the blood for the patient.
Conclusion: The principle of anesthesia management in TGA cases is to avoid a reduction in cardiac output and SVR and keep the PVR lower than the SVR.

Keywords: Balloon atrial septostomy; Pulmonary vascular resistance; Systemic vascular resistance; Transposition of the great arteries.

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INTRODUCTION

TGA (transposition of the great arteries) accounts for 7–8% of all congenital cardiac anomalies, with an incidence rate of 0.2 per 1000 live births. TGA can be fatal to an infant without surgery, with a 30% mortality rate in the first week and a 90% mortality rate in the first year. Left-to-right shunting is the most dependable technique to boost systemic oxygen delivery in TGA babies. But, in the TGA babies with severe cyanosis, Balloon atrial septostomy (BAS) is immediately indicated [1].

Infants and newborns have immature respiratory control, ineffective respiratory muscles, altered airway and lung mechanics, and a more significant basal metabolic oxygen requirement. Then, greater Fetal Hemoglobin levels in babies at risk of perioperative hypoxia and anesthetic drugs may impede the ventilatory response to hypoxia and hypercarbia. In addition, neonates cannot endure increased pre- and post-load, myocardial depression, hypovolemia, or arrhythmia. Elevated pulmonary vascular resistance (PVR) can manifest as 'poor mixers' in TGA newborns. Because of these changes, young children are more susceptible to anesthesia-related critical events, such as cardiac arrest. Thus, the anesthesiologist needs appropriate anesthetic plans to administer anesthesia to avoid morbidity and mortality two. Therefore, we report an anesthetic management case of a 1-day-old newborn baby who underwent a BAS procedure for TGA.

CASE ILLUSTRATION

A 1-day-old baby was referred to Dr. Moewardi General Hospital for shortness of breath and blue lips when crying. While at the previous hospital, the patient had early CPAP installed but was still short of breath, so she was given CPAP with PEEP 7.0 FiO2 100%. She was treated in the previous hospital neonatal HCU with CPAP PEEP 7.0 FIO2 40% oxygenation. The patient could still cry intensely, move actively, and have a good tone. Then, the patient was referred to Dr. Moewardi General Hospital with a nasal cannula of 0.5 lpm. When the patient arrived, he looked at cyanosis and had a retraction of the respiratory muscles. The oxygen was increased to 1 lpm, the baby looked calm and comfortable, and the cyanosis disappeared with minimal retraction.

The patient had a history of spontaneous birth, APGAR Score 6,7,8 at 41 weeks gestational age, and crying after getting stimulation. The patient's

birth weight was 3300 grams, with a birth length of 50 cm. Antenatal care history of mothers who are not routinely checked by a doctor and diagnosed with severe preeclampsia.

The physical examination showed cyanosis of the lips when crying and retraction of the respiratory muscles. The patient had a one lpm nasal cannula inserted. The patient's heart rate was 130 beats per minute, a noisy breathing rate of 50 breaths per minute, SiO2 84-89%, capillary refill time <2 seconds.

Initial laboratory examinations showed no anemia (Hemoglobin 20.4 g/dl, hematocrit 61%, and erythrocytes 6.01 million/ul). Platelets within normal limits of 268 thousand/ul, leukocytes within normal limits of 20.1 thousand/ul, PT within normal limits of 14.3 seconds, APTT slightly prolonged 46.8 seconds, INR 1,140, SGOT slightly increased 49 u/l, SGPT within normal limits 17 u/l, creatinine slightly increased by 1.1 mg/dl, urea slightly increased by 47 mg/dl, electrolytes within normal limits, and blood type O. Babygram chest radiograph showed no abnormalities in cast and pulmo, and gastric tube with a tip projected into the stomach. The echocardiography results showed atrial situs solitus AV-VA concordance site, normal systemic and pulmonary venous drainage, heart chamber balance, PFO diameter of 3.5 mm and PDA of 2.2 mm, transposition of the aorta, and aortic arch on the left. It was concluded that TGA and ventricular septal defect (VSD) (Figure 1).

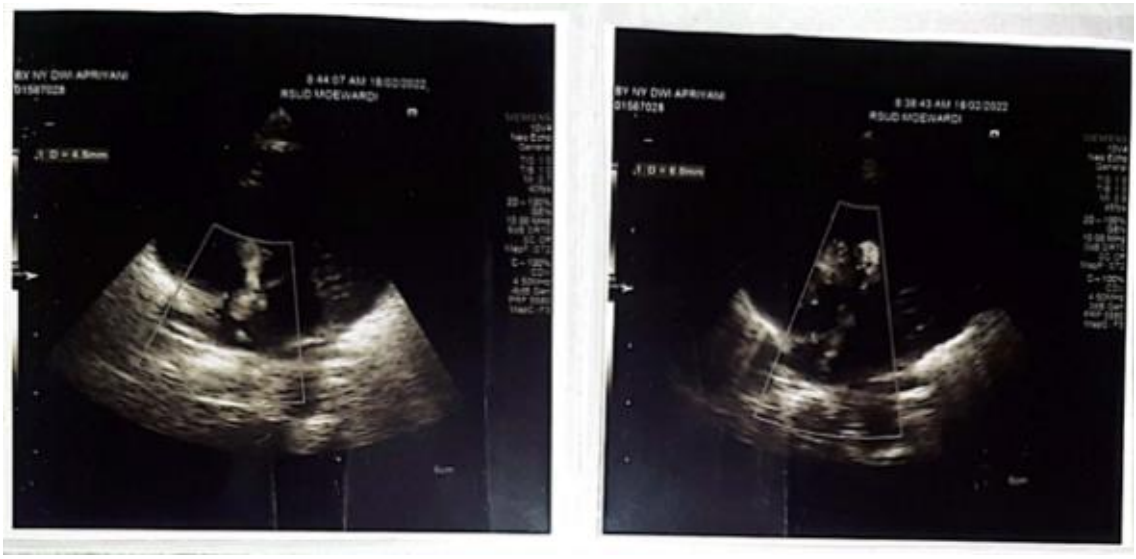

Figure 1. Echocardiography of a 1-day-old baby

The patient was in Dr Moewardi General Hospital Neonatal HCU for two days before undergoing a BAS procedure. The patient's state was progressively weaker and bluer, with inadequate respiratory patterns; her weeping was feeble, and her movements were passive. The patient's oxygen saturation was between 69 and 73%. Due to that condition, he needs a BAS procedure as early treatment. The patient had received intravenously prophylactic antibiotics, cefazolin injection 75 mg/12 hours (25 mg/kg body weight/12 hours), and ampicillin injection 150 mg/12 hours (50 mg/kg body weight). /12 hours) and maintenance fluid NS 0.9%, D5 NS intravenous infusion with an intravenous catheter using a macro drip set at 18 cc/hour (maintenance fluid and fluid replacement for mild stress in procedure) with an infusion pump. We maintain ductal patency with PGE1 0.01–0.05 μg/kg/minute.

The patient was allowed to drink breast milk until 4 hours before the procedure. The patient's parent or guardian signed the informed consent. Then, the patient was taken to the operating room.

The operating room preparation was done by turning off the air conditioner, maintaining the room at a temperature of 26 °C-29 °C, and placing a heating blanket on the operating table as passive insulation skin warming. When the patient entered the operating room, an O2 saturation monitor and electrocardiography were installed to maintain contractility, preload, O2 saturation, and heart rate to preserve cardiac output, and continuous temperature monitoring was performed to avoid hypothermia or hyperthermia. His blood pressure was 91/36 mmHg, heart rate (HR) was x/minute, respiration rate (RR) was 48 x/minute, SpO_2 was 70%, and body temperature was 36.7^{o}C. ECG showed a picture of sinus rhythm tachycardia. The patient was given oxygenation at 4 L/min using a face mask through Jackson Reese; the SpO_2 was 77%.

Anesthetic preparations include administration of atropine sulfate (SA) 0.01-0.2 mg/kg IV (0.1 mg). Induction was performed with a combination of ketamine 0.5 mg/kg IV (1.5 mg) and midazolam 1 mg/cc; the patient was induced with Sevoflurane gas steal induction until it reached the depth of anesthesia for surgery, given

the steroid dexamethasone 0.1-0.5 mg /kg IV (1 mg), facilitate intubation with Atracurium at a dose of 0.5 mg/kgBB IV (1.5 mg), intubate with an endotracheal tube (ETT) no 3.0 non-cuff 9 cm deep. Maintenance with Oxygen: air bar = 2: 2 L/minute. Sevoflurane 2.5 – 3.2 vol%. The drugs entered during surgery are an epinephrine syringe pump of 0.05 mg/kg/minute (0.1 – 0.2 cc/hour) and a morphine bolus of 0.1 mg/kg (0.3 mg) if SpO_2 is below 50%.

Initial incision using Fentanyl 2.5 mcg/cc. Septostomy was performed using a 6 F Fogarty Dilatation Catheter through the right femoral vein. Heparin 560 units IV was given. Then the diagnostic catheter JR 3.5/5 Fr and guidewire command 18 LT 0.018 x 300 cm was inserted into the left atrium, then ASD (atrial septal defect), and return to the left atrium. It was evaluated and then removed. Then, the Z-5 atrioseptostomy balloon was inserted through the femoral vein into the right atrium, then ASD and left atrium, and the balloon was inflated and evaluated. If the procedure is successful, the balloon will be removed. The patient had ten cc bleeding and was not given a transfusion. The duration of the BAS procedure was 1 hour 30 minutes, and the time of anesthesia was 2 hours 30 minutes. The procedure was successful by opening the ASD for 4 mm with no complications. During surgery, the patient was supine, and the condition was relatively stable, with monitoring of blood pressure, SaO_2, and heart rate every 15 minutes (Figure 2).

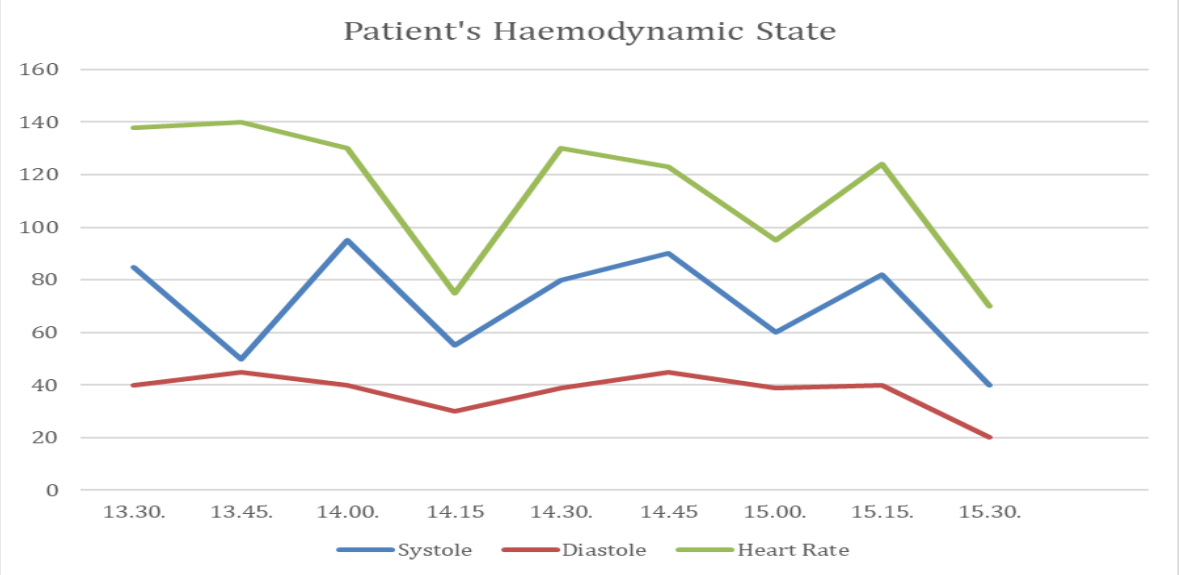

Figure 2. Intraoperative hemodynamic of a 1-day-old baby

After the procedure, the patient was extubated and transferred to the neonatal HCU room in an incubator covered with cotton blankets. Before being transferred, the hemodynamic arterial blood pressure was 96/38 mmHg, HR 147x/minute, RR 30 x/minute, and SpO_2 80% with a one lpm nasal cannula installed.

When admitted to the Neonatal HCU, the baby was still under sedation with an arterial blood pressure of 70/49 mmHg, HR 152 x/minute, RR 30 x/minute, and SpO_2 80%. The patient was given a follow-up antibiotic with ampicillin 150 mg/12 hours IV (50mg/ KgBW/12 hours). Targeted temperature management (TTM) in the NICU, continuous temperature monitoring, and active fever prevention in critically ill neonatal patients are paramount. The laboratory examinations showed Hb 20.0 g/dl, Ht 57%, leukocytes 20.0 thousand/uL, platelets 234 thousand/uL, PT: 15.8 seconds, aPTT: 56.8 seconds, and albumin 3.9 g/dL.

DISCUSSION

TGA patients have an unbalanced ratio of total pulmonary blood flow (Q_P) to total systemic blood flow (Q_S). Therefore, individuals with TGA require one or more cardiac chamber communications (e.g., Atrium Septal Defect, Patent Ductus Arteriosus, Patent Foramen Ovale, and Ventricular Septal Defect) to facilitate inter-circulatory mixing. Intercirculatory mixing allows oxygenated blood to reach all parts of the body[1].

BAS (Balloon Atrial Septostomy) is a procedure to increase oxygenation in TGA patients by creating an atrial septal defect to improve the inter-circulatory mixing before they undergo definitive surgical treatment. Before corrective surgeries, such as arterial switch surgery, the BAS method aims to enhance the hemodynamic condition so that stable patients can undergo the procedure [3]. BAS has been shown to lengthen the period before the definitive surgery effectively. An increase in oxygen saturation indicates the BAS procedure's success.

According to research by Al-Kassmy et al., patients with dextro-transposition of the great artery (d-TGA) who underwent the BAS operation significantly improved oxygen saturation. It showed that the increase in oxygen saturation value was about 18.91% ± 12.95% points [3].

However, the BAS procedure has many risks, including femoral or

umbilical vein trauma, atrial arrhythmia, complete cardiac block, and pulmonary vein or inferior vena cava avulsion. It increases the risk of thromboembolic events in the brain [4–6].

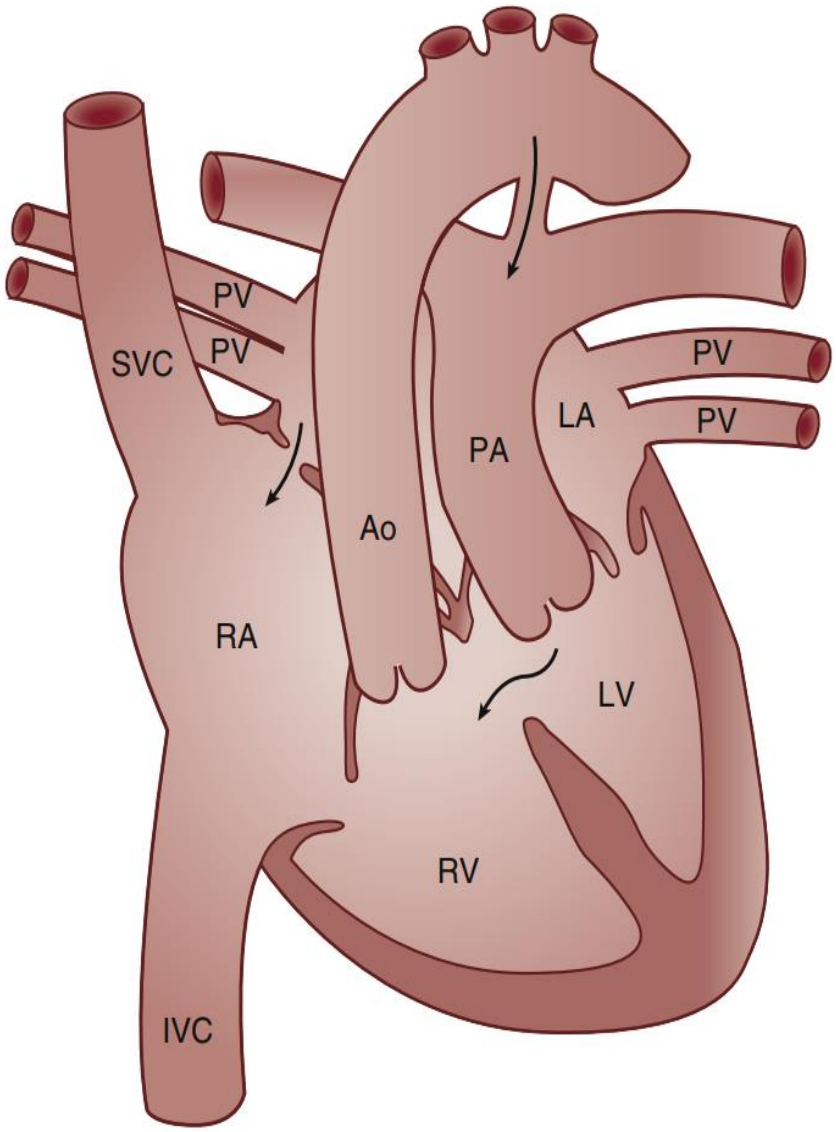

Figure 3. Transposition of Great Arteries. The right ventricle (RV) and left ventricle (LV) are connected in parallel to each other, creating independent circulations, with the aorta (Ao) arising from the RV and the pulmonary artery (PA) arising from the LV. Through an ASD (atrial septal defect), VSD (ventricular septal defect), or PDA (patent ductus arteriosus), blood must be mixed between the two circulations to survive. IVC, Inferior vena cava; LA, left atrium; PV, pulmonary vein; RA, right atrium; SVC, superior vena cava [7].

In this patient, BAS is important to be done immediately because of the condition of the TGA patient with VSD (without ASD). Cases of cyanotic heart defects require sufficient blood mixing at the atrial level to sustain life. A small, restrictive ASD will lead to inadequate blood mixing, persistent hypoxia, and metabolic acidosis. BAS can be performed before the age of 6 weeks. If executed on a patient older than six weeks old, it will increase the thickness of the atrial septum [6].

We present a case of TGA with VSD. Anesthetic management in this patient was challenging since the patient was a 3-day-old newborn girl with cyanotic presentation. Neonates' respiratory and cardiovascular physiology differs from older children and adults, making them more vulnerable to perioperative respiratory and cardiocirculatory problems. During anesthesia, they poorly tolerate myocardial contractility depression and changes in systemic vascular resistance or circulatory volume [2].

Several other case reports have discussed anesthesia management in patients with inter-circulatory mixings, such as TGA. However, most focus on the arterial switch operation (ASO) method, distinct from the BAS operation. Therefore, the anesthetic management strategy may change. ASO is one of the definitive correction methods of TGA. However, in some instances with minimal inter-circulatory mixing, BAS is required [6].

The goal of anesthetic management in TGA is to maintain heart rate, contractility, and preload to maintain cardiac output and to avoid a decrease in arterial saturation. Pulmonary vascular resistance (PVR) and systemic vascular resistance (SVR) must be held to maintain hemodynamic stability. Anesthesiologists must avoid increasing PVR relative to SVR because it can decrease pulmonary blood flow and reduce inter-circulatory mixing. Furthermore, a reduction of SVR relative to PVR should be avoided so that recirculation of systemic venous blood will not increase and arterial saturation will not decrease (1). SpO_2 was kept between 70-80%. TGA requires a QP: QS ratio close to 1:1, as shown in the 80% systemic SpO_2. High SpO_2 levels (>90%) result in abundant pulmonary perfusion but poor systemic perfusion and potentially cause lactic acidosis. In addition, high SpO_2 levels will increase

pulmonary blood flow and can cause pulmonary edema by increasing intravascular hydrostatic pressure [8]. Low SpO_2 (<70%) causes inadequate pulmonary perfusion and excessive systemic perfusion. Anesthesiologists also should manage the patency of the shunt in TGA. Prostaglandins' administration keeps the patent ductus arteriosus (PDA) patency [5].

Premedication was carried out using atropine sulfate. Induction was performed with a combination of midazolam and ketamine to reduce the side effects while optimizing induction quality. According to a study in 2018, the combination of intranasal midazolam with ketamine in children aged 1-10 years provides better quality of sedation, analgesia, and retention of comfort than single induction with either midazolam or ketamine [9].

Ketamine is a rapid-acting anesthetic that causes a condition of profound analgesia, preservation of the pharyngeal-laryngeal reflexes, normal or slightly improved skeletal muscle tone, antidepressant effects, and occasionally temporary and minor respiratory depression. The action mechanism of ketamine is mainly by noncompetitive antagonism of the N-methyl D-aspartic acid (NMDA) receptor. Ketamine is well known for its stimulating effect on the cardiovascular system, primarily mediated through sympathetic nervous system activation. This makes it a desirable alternative to anesthetics with poor hemodynamic profiles [10]. Ketamine is frequently used in heart disease, shock, and hypotension patients. Ketamine is preferable in maintaining hemodynamic stability since it raises SVR and PVR while also inducing drowsiness without producing respiratory depression [5,11].

Induction continued with sevoflurane gas steal induction until it reached the depth of anesthesia for surgery. This depth of anesthesia is required to keep a left-to-right shunt. Sevoflurane is a halogenated volatile anesthetic agent, has the highest hemodynamic stability, is non-irritating to the respiratory tract, and possesses bronchodilator activity. Faster induction and recovery make sevoflurane the best volatile-inducing agent. Moreover, it has minimal side effects on hemodynamic changes, particularly in individuals at risk for cardiovascular dysfunction[12]. Sevoflurane is safe, reliable, quick, and well tolerated by patients and is used to keep PVR lower than SVR [11,13].

Anesthesia was maintained with Oxygen: air bar = 2: 2 L/minute and Sevoflurane. Sevoflurane is less irritating to the airways, less hemodynamically impacted, and has lower odor acuity than desflurane and isoflurane [14]. Ketamine and fentanyl were administered to patients as multimodal analgesia since it helps to avoid opioid dependency as well as opioid-related side effects [15,16]. Neonatal patients usually get ketamine because of its ability to sustain hemodynamics by raising SVR and PVR. Moreover, ketamine can enhance fentanyl's antinociception without affecting the sedation index [5,13,14].

The neonatal vulnerability associated with hypothermia is related to several aspects, including less effective regulatory abilities compared to adults, a lesser weight-to-surface area (WSA) ratio, increased heat loss from the head, a limited amount of subcutaneous fat storage for thermal insulation, and the inability of the neonate to move to a warmer environment or wear warmer clothing. Moreover, newborns cannot increase their metabolic rate in the case of intraoperative hypothermia, just like adults cannot. Hence, an excellent perioperative warming strategy is required, including accurate core temperature assessment, maintenance of normothermia during transportation, active warming before anesthesia induction and throughout and surgery. When fluids must be administered to the patient, we need infusion warming. We can also control the efficacy of active warming therapy and prevent overheating children by measuring core temperature [10].

CONCLUSION

Anesthesia management of TGA TGA cases is to avoid reducing cardiac output and SVR and keep the PVR lower than the SVR. The administration of an anesthetic regimen for newborns with TGA must consider circulatory and pulmonary physiology and the patient's clinical status.

CONFLICT OF INTEREST

The Authors declare that they have no conflict of interest.

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