Anesthesia for percutaneous transcatheter closure of atrial and ventricular septal defects in pediatric patients

Ayşe Heves Karagöz[1], Aysun Ankay-Yılbaş[2], Meral Kanbak[1], Murat Tümer[1], Süheyla Özkutlu[3], Tevfik Karagöz[3]

[1]Department of Anesthesiology and Reanimation and [3]Division of Pediatric Cardiology, Department of Pediatrics, Hacettepe University Faculty of Medicine, Ankara, and [3]Clinics of Anesthesiology and Reanimation, Akçaabat Haçkalı Baba State Hospital, Trabzon, Turkey E-mail: aysunankay@hotmail.com

SUMMARY: Karagöz AH, Ankay-Yılbaş A, Kanbak M, Tümer M, Özkutlu S, Karagöz T. Anesthesia for percutaneous transcatheter closure of atrial and ventricular septal defects in pediatric patients. Turk J Pediatr 2013; 55: 628-632.

We aimed to investigate the anesthetic management of percutaneous closure of atrial and ventricular septal defects (ASD/VSD) in pediatric patients. A retrospective review of the anesthetic data of 351 patients who underwent transcatheter closure of ASD/VSD was conducted. The mean age was 8.42 ± 5.71 years (4 months-18 years). VSD closure was performed in 52 patients and the remaining 299 had a procedure for ASD closure. All patients were premedicated with midazolam. All procedures were performed under general anesthesia in the catheterization laboratory. After anesthesia induction with sevoflurane or intravenous anesthetics, all patients were intubated. The procedure was completed without any complications in 98.3% of patients. Many anesthetic drugs have been used for pediatric cardiac catheterization, but it cannot be concluded whether there is an ideal anesthetic method. Regardless of the method, the anesthesiologist must consider not only the need for adequate analgesia and immobility but also that for hemodynamic stability during the procedure.

Key words: pediatric anesthesia, ventricular septal defect, atrial septal defect.

Since the mid 1990s, rapid technologic and medical advancements have made the use of interventional procedures like percutaneous closure of atrial septal defects (ASD), patent ductus arteriosus (PDA) and ventricular septal defects (VSD) as widely used as diagnostic catheterizations both in pediatric and adult patient groups[1,2]. The transcatheter device closure of cardiac and extracardiac defects is usually preferred because of reduced morbidity and mortality, shorter hospital stay, superior cosmetic results, decreased cost, and less postoperative pain[1]. It is also gaining in popularity due to high success rates and greater patient comfort[3].

Interventional catheterization procedures require an immobile patient with stable hemodynamics. Hemodynamic instability such as hypotension, sudden hypertension, and tachycardia from the pain of balloon angioplasty, arrhythmia, heart block, blood loss, and pulmonary hypertension (PHT) should be treated immediately[4]. Transesophageal echocardiography (TEE), which is an essential part of the procedure, is also very uncomfortable for the patients. Despite there being only a few reports that mention ketamine and midazolam usage for interventional catheterizations administered by the cardiologist[5], many centers now prefer to perform this procedure in the presence of an anesthesiologist, especially in children, because of the risks of the procedure itself and the anesthetic techniques and the need for skilled airway management and resuscitation[4].

Many anesthetic agents are discussed for anesthesia in percutaneous transcatheter closure of ASD/VSD, but the studies including intubated patients undergoing general anesthesia usually have a limited number of patients. Therefore, we aimed to discuss the anesthetic management of percutaneous closure of ASD/VSD and to examine the frequency of the complications related to the procedure itself and anesthetic management in the pediatric age group.

Material and Methods

After local ethical committee approval, a retrospective review of anesthesia management data for transcatheter closure of ASD/VSD was conducted. All pediatric patients (n=351) who underwent percutaneous ASD/VSD closure from 2004-2012 were included in the study.

Age, sex, body weight, American Society of Anesthesiologists (ASA) class, concomitant diseases, presence of PHT, procedure type, procedure time, anesthesia time, ASD/VSD size, device size, incidence of failure to deploy the device, incidence of need for surgery, anesthetic drugs used, complications seen during or after the procedure, and hospitalization time in the cardiac intensive care unit (ICU) were recorded for all patients.

All patients underwent preanesthetic evaluation one to two days before the procedure. Following a fasting period ranging from 4-8 hours depending on the age of the patient, children younger than 8 years of age were premedicated with oral midazolam 0.5 mg kg^{-1} with a maximum dose of 15 mg, 15 minutes before entering the catheterization laboratory, and children older than eight years of age were premedicated with intravenous (iv) midazolam 0.01 mg kg^{-1}, 5 minutes before entering the catheterization laboratory, as the standard procedure of our clinic. Standard monitoring with a 5-lead electrocardiogram, non-invasive blood pressure, pulse oximeter, and capnography were applied to all patients. After placement of the femoral arterial sheath side port, invasive arterial blood pressure was also monitored. General anesthesia was induced with 8% sevoflurane in 50% oxygen-air mixture through our anesthesia machine (Datex Ohmeda ADU S-5) or with iv anesthetics in children whose iv catheter were placed before premedication.

The time from induction of anesthesia to tracheal extubation was recorded as anesthesia time. The time from initiation of vascular cannulation by the cardiologist to removal of the catheters was recorded as procedure time. PHT was defined as mean pulmonary artery pressure ≥25 mmHg.

After the induction of anesthesia, TEE monitoring was performed during all procedures by the same pediatric cardiologist. GE Medical System Model 6Tv, Horten, Norway (adult size, 10 mm body, 14 mm head) and GE Vingmed ultrasound, Horten, Norway (pediatric TEE probe, 7 mm body, 10 mm head) are used for children >15 kg and <15 kg, respectively.

All analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 16.0 (SPSS, Inc., Chicago, IL) statistical software. Continuous data were summarized as the mean ± standard deviation (SD), and categorical data were summarized as counts and percentages.

Results

A total of 351 patients (153 male, 198 female) with a mean age of 8.42 ± 5.71 years (range: 4 months-18 years) who underwent

Table I. Demographic and Procedure Data

	ASD (n=299)		VSD (n=52)	
	Range	Mean±SD	Range	Mean±SD
Age (years)	0-18	8.23 ± 5.16	0-18	9.50 ± 8.15
Weight (kg)	4-97	28.13 ± 15.96	3-79	31.20 ± 20.93
Sex (male/female)	125/174	-	28/24	-
ASA class II/III	294/5	-	52/0	-
Defect size (mm)	3-45	13.68 ± 6.11	1-12	5.32 ± 2.49
Device size (mm)	5-35	16.83 ± 5.91	4-10	6.85 ± 1.61
Anesthesia time (min)	18-120	59.62 ± 22.28	30-150	93.93 ± 34.96
Procedure time (min)	14-110	50.84 ± 21.18	20-147	85.33 ± 36.02
Procedure failure/Surgery requirement (n)	70/57	-	9/4	-
Procedures with complication (n)	74	-	11	-

percutaneous ASD/VSD closure from 2004-2012 were included in the study. Demographic and procedure data are presented in Table I.

The ASA class was found to be II for 98.6% of patients (346 patients) and III for 1.4% of patients (5 patients). The most commonly seen concomitant diseases were asthma (4 patients), pulmonary stenosis (4 patients), tricuspid insufficiency (3 patients), and Down syndrome (3 patients). Two hundred ninety-five patients (84%) were diagnosed incidentally. The most common presenting symptoms in the rest of the patients were palpitation (3.4%), chest pain (3.7%), and fatigue and weakness (2.3%). Since our procedures are selected from small or moderate VSDs, PHT was less than expected rates (5.7% of patients).

Percutaneous VSD closure was performed in 52 patients (14.8%); the remaining 299 patients (85.2%) had the procedure for ASD closure. Mean procedure time was 55.72 ± 26.52 minutes and the mean anesthesia time was 64.52 ± 27.11 minutes. Mean sizes of the ASD/VSDs percutaneously closed were 13.68 ± 6.11 mm and 5.32 ± 2.49 mm, respectively. Amplatzer septal occluder (AGA Medical Corp, MN, USA) was used in 98.3% and Occlutech Figulla ASD occluder (Occlutech GmbH, Jena, Germany) was used in the remaining 1.7% of patients.

All procedures were performed under general anesthesia. Anesthesia induction was performed with propofol in 80.3% (iv, 2-3 $mg.kg^{-1}$), with 8% sevoflurane in 50% oxygen-air mixture in 1.8%, with thiopental in 2.2% (iv, 3-5 $mg.kg^{-1}$), and with ketamine in 7.2% (iv, 1-2 $mg.kg^{-1}$) of patients. Anesthesia was maintained with 2% sevoflurane in 50% oxygen-N_2O mixture in all patients. Fentanyl iv, 1 $\mu g.kg^{-1}$, was applied to all patients after anesthesia induction for intraoperative analgesia. Fifty-two patients (14.8%) needed an additional dosage of 1 $\mu g.kg^{-1}$ fentanyl during the procedure. All patients were intubated, and the most preferred agents for neuromuscular blockade were vecuronium bromide (33.3%) (iv, 0.1 $mg.kg^{-1}$) and rocuronium bromide (63.8%) (iv, 0.5 $mg.kg^{-1}$).

The procedure was completed without any complications in 75.8% of patients. One patient had severe bradycardia during the procedure and was treated with atropine. Complications related to the device occurred in 3 patients and dilatation of ASD during the procedure was seen in 2 patients. There was failure to deploy the device in 79 patients (22.9%). The most common reasons for failure were inappropriately small device choice (17 patients), presence of a large defect (16 patients), presence of two defects (8 patients), and the position of the defect (3 patients). Sixty-one patients (17.6%) required surgery; the ASD/VSD of the remaining 18 patients were closed in a second session. No complications related to anesthesia were observed. None of the patients received blood transfusions.

After the procedure, all patients were hospitalized for routine monitoring in the cardiac ICU. The mean discharge time from the cardiac ICU was 1.87 ± 1.24 days. Three hundred fifty patients (99.7%) were discharged from the hospital without any complications during the hospitalization time. A 13-year-old patient with bradycardia (heart rate 42 beats/min) was treated with 0.02 mg kg^{-1} atropine.

Discussion

Percutaneous transcatheter closure of ASD/VSD requires general anesthesia or sedation because of the need for a completely immobile patient and the risk of hemodynamic instability. Hemodynamic effects that should be given particular attention during the procedure include hypertension and tachycardia for ketamine, low systemic vascular resistance for propofol, and hypotension and bradycardia for dexmedetomidine[6]. Kogan et al.[7] and Tosun et al.[6] found a mixture of propofol-ketamine to be a safe and practical alternative to general anesthesia in children. Some studies showed that adding dexmedetomidine to sedation with propofol was well tolerated with a shorter recovery time, decreased movement and reduced need for airway intervention[8,9]. In the study of Lebovic et al.[10] in the pediatric age group, propofol infusion with fentanyl for analgesia was also associated with significantly shorter recovery times than ketamine/midazolam anesthesia. In another retrospective study of 106 adult patients undergoing percutaneous ASD closure under general anesthesia in our center[11], no major complications with propofol and fentanyl anesthesia were observed. We used propofol, ketamine, thiopental, and

sevoflurane for anesthesia induction. Anesthesia was maintained with 2% sevoflurane in 50% oxygen-N_2O mixture in all patients. Fentanyl was applied to all patients for intraoperative analgesia. In this study, we collected data from an eight-year experience. In the first years of our clinic, we chose ketamine due to the low risk of hypotension and bradycardia. However, we later used different anesthetic agents and did not face any hemodynamic instability during the procedure except in one patient with severe bradycardia.

Laussen et al.[12] used sedation for the closure of muscular VSDs in their series in the beginning, but they later changed their anesthetic management and started to use general anesthesia because of high urgent intubation need due to hemodynamic instability. Kapoor et al.[1] also used general anesthesia in their retrospective review of nine children undergoing elective percutaneous transcatheter closure of perimembranous VSDs. Although general anesthesia alters venous return and pulmonary vascular tone and may consequently hinder accurate hemodynamic assessment[1], we also preferred general anesthesia in our patients. The presence of a stable airway and ventilation method is necessary should complications like arrhythmia, heart blocks, hypotension, or air emboli occur. We also believe that a supine and motionless position during the procedure and TEE can be very uncomfortable for the children when not under sedation or general anesthesia.

In the study of Kapoor et al.[1], five patients had multiple episodes of transient bundle branch block, one patient developed complete heart block, one patient developed device embolization, and two patients developed persistent hypotension during the procedure.

In septal defects, PHT due to shunting of blood from the systemic to pulmonary circulation may lead to right ventricular failure, Eisenmenger syndrome and death. In an epidemiologic study of 1824 adult patients with a septal defect, PHT prevalence was found as 6.1%[13]. Another study including adult patients found PHT prevalence as 34% in patients with an open ASD, 28% in patients with an open VSD, and 12% and 13% in patients with closed defects, respectively[14]. PHT was seen in 5.7% of patients in our study. This low ratio may be due to the young age and small-to-medium-sized defects seen in most of our patients.

In the study of Laussen et al.[12], 40% of the patients required treatment with inotropic agents or pacing. Celiker et al.[15] reported their experience of percutaneous ASD closure with Amplatzer septal occluder in 80 children. In their study, there were no major complications like device fracture, embolization, migration, or major arrhythmias. Minor and transient rhythm abnormalities were observed in five patients and trivial mitral regurgitation was seen in six patients. Further, no major arrhythmias occurred in Karagoz et al.'s study[11] performed in an adult age group. Bradycardia developed in one patient during the procedure and in two patients after the procedure. The mortality rate was 0.9% (1 patient developed an infarct in the middle cerebral artery territory during the procedure). A large study of 3850 device closures of ASD in children reported no device-related deaths. The rate for major complications (tamponade, stroke, myocardial infarction, device embolization, and major bleeding) was 0.3% and that of minor complications (arrhythmias, minor bleeding and bruising) was 2.8%[16]. The procedure was completed without any complications in 75.8% of patients in our study. There was failure to deploy the device in 79 patients. One patient had severe bradycardia during the procedure. Complications related to the device occurred in three patients, and dilatation of ASD during the procedure was seen in two patients. No anesthesia-related complications were seen. We used different anesthetic agents for anesthesia induction and maintenance and achieved hemodynamic stability in our patients. We believe that further prospective randomized studies are needed to compare the hemodynamic effects of different drugs during percutaneous ASD/VSD closure.

Although many anesthetic drugs have been used for pediatric cardiac catheterization, the presence or not of an ideal anesthetic method remains to be concluded. Regardless of the method, the anesthesiologist must consider not only the need for adequate analgesia and immobility but also that for hemodynamic stability during the procedure

REFERENCES

1. Kapoor MC, Sharma S, Sharma VK, Dugal JS, Singh C. Anesthesia for percutaneous transcatheter closure of perimembranous ventricular septal defect. J Cardiothorac Vasc Anesth 2006; 20: 202-208.
2. Oklü E, Bulutcu FS, Yalçin Y, Ozbek U, Cakali E, Bayindir O. Which anesthetic agent alters the hemodynamic status during pediatric catheterization? Comparison of propofol versus ketamine. J Cardiothorac Vasc Anesth 2003; 17: 686-690.
3. Calvert PA, Klein AA. Anaesthesia for percutaneous closure of atrial septal defects. Continuing Education in Anaesthesia Critical Care & Pain 2008; 8: 16-20.
4. Andropoulos DB, Stayer SA. An anesthesiologist for all pediatric cardiac catheterizations: luxury or necessity? J Cardiothorac Vasc Anesth 2003; 17: 683-685.
5. Jobeir A, Galal MO, Bulbul ZR, Solymar L, Darwish A, Schmaltz AA. Use of low-dose ketamine and/or midazolam for pediatric cardiac catheterization. Pediatr Cardiol 2003; 24: 236-243.
6. Tosun Z, Akin A, Guler G, Esmaoglu A, Boyaci A. Dexmedetomidine-ketamine and propofol-ketamine combinations for anesthesia in spontaneously breathing pediatric patients undergoing cardiac catheterization. J Cardiothorac Vasc Anesth 2006; 20: 515-519.
7. Kogan A, Efrat R, Katz J, Vidne BA. Propofol-ketamine mixture for anesthesia in pediatric patients undergoing cardiac catheterization. J Cardiothorac Vasc Anesth 2003; 17: 691-693.
8. Ülgey A, Aksu R, Bicer C, et al. Is the addition of dexmedetomidine to a ketamine-propofol combination in pediatric cardiac catheterization sedation useful? Pediatr Cardiol 2012; 33: 770-774.
9. Koruk S, Mizrak A, Kaya Ugur B, Ilhan O, Baspinar O, Oner U. Propofol/dexmedetomidine and propofol/ketamine combinations for anesthesia in pediatric patients undergoing transcatheter atrial septal defect closure: a prospective randomized study. Clin Ther 2010; 32: 701-709.
10. Lebovic S, Reich DL, Steinberg LG Vela FP, Silvay G. Comparison of propofol versus ketamine for anesthesia in pediatric patients undergoing cardiac catheterization. Anesth Analg 1992; 74: 490-494.
11. Karagoz H, Yilbas AA, Ayhan B, Kaya EB, Kanbak M. Anesthesia for percutaneous transcatheter closure of atrial septal defects in adults. Anadolu Kardiyol Derg 2012; 12: 371.
12. Laussen PC, Hansen DD, Perry SB, et al. Transcatheter closure of ventricular septal defects: hemodynamic instability and anesthetic management. Anesth Analg 1995; 80: 1076-1082.
13. Duffels MG, Engelfriet PM, Berger RM, et al. Pulmonary arterial hypertension in congenital heart disease: an epidemiologic perspective from a Dutch registry. Int J Cardiol 2007; 21: 198-204.
14. Engelfriet PM, Duffels MG, Möller T, et al. Pulmonary arterial hypertension in adults born with a heart septal defect: the Euro Heart Survey on adult congenital heart disease. Heart 2007; 93: 682-687.
15. Celiker A, Ozkutlu S, Karagoz T, Ayabakan C, Bilgic A. Transcatheter closure of interatrial communications with Amplatzer device: results, unfulfilled attempts and special considerations in children and adolescents. Anadolu Kardiyol Derg 2005; 5: 159-164.
16. Omeish A, Hijazi ZM. Transcatheter closure of atrial septal defects in children & adults using the Amplatzer Septal Occluder. J Interv Cardiol 2001; 14: 37-44.