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Anesthesia management in pediatric patients undergoing percutaneous closure of atrial and ventricular septal defects in catheter laboratory: Retrospective clinical study

Sedat Akbas, Ahmet Selim Ozkan

Inonu University, Faculty of Medicine, Department of Anesthesiology and Reanimation, Malatya, Turkey

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Abstract

Along with technological and medical advances, diagnostic and therapeutic cardiac catheterization commonly used in pediatric patients; it is frequently preferred the percutaneous closure of ASD/VSD. In this study, it was aimed to evaluate anesthesia management of pediatric patients undergoing percutaneous closure of ASD/VSD in catheter laboratory. This was a retrospective review of pediatric patients undergoing percutaneous closure of ASD/VSD in catheter laboratory between 2012–2017. Demographic and clinical characteristics were recorded, and all results of anesthesia management were evaluated. Thirty-eight patients (18 males, 20 females) with a mean age of 7,71 ± 3,57 years underwent percutaneous closure of ASD/VSD. Of the cases; 78,4% diagnosed ASD, 21,6% diagnosed VSD were operated. The most common presenting symptoms were murmur (55,3%), chest pain (21,1%) and palpitation (10,5%), Mean defect size was 11.60 ± 6.27 mm for ASD and 6.00 ± 4.64 mm for VSD. Mean anesthesia time was 71.33 ± 22.77 minutes for ASD and 85.83 ± 26.91 minutes for VSD. Mean procedure time was 56.00 ± 20.56 minutes for ASD and 69.16 ± 28.70 minutes for VSD. Premedication was performed for 94,7%, anesthesia induction was performed with propofol (94,7%), fentanyl (63,2%), rocuronium (65,8%). Sevoflurane was used for anesthesia maintenance. TEE was used in 86,8% of the cases. Complications developed for 3 cases. IV paracetamol was preferred in 84,2%. Anesthetist must consider carefully premedication, anesthetic agent preferences, general anesthesia or sedation, complications by catheterization, discomforts of transesophageal echocardiography, hemodynamic instability, requirement of immobility and adequate analgesia.

Keywords: Anesthesia management, pediatric cardiac catheterization, heart septal defects

Introduction

Along with technological and medical advances, it is moving away from conventional surgical procedures and the number of minimal invasive or even noninvasive procedures are increasing. In the light of these developments, diagnostic and therapeutic cardiac catheterization commonly used in pediatric patients; it is frequently preferred the percutaneous closure of atrial septal defect (ASD) and ventricular septal defects (VSD) in catheter laboratory [1,2].

Especially percutaneous closure of cardiac defects is preferred because of decreasing morbidity and mortality, shortening the length of hospital stay, cost reduction, better cosmetic results and less postoperative pain. In addition, its popularity is increasing due to high success rates and greater comfort [2,3].

Immobility and hemodynamic stability of the patient are very important in interventional catheterization procedures. Sudden hypotension and hypertension, hemodynamic complications such as tachycardia, arrhythmia, heart block and blood loss which may be caused by balloon angioplasty and transesophageal echocardiography (TEE) induced pain should be treated [4,5]. Because of TEE, which is uncomfortable and an indispensable part of the process, the risks of the procedures and especially the difficulties of airway management and hemodynamic stability in children, anesthesiologists are required to accompany the interventional catheterization procedures [6].

In this study, it was aimed to evaluate anesthesia management of pediatric patients undergoing percutaneous closure of atrial and ventricular septal defects (ASD/VSD) in catheter laboratory in terms of the requirement of premedication, anesthetic agent preferences, sedation or general anesthesia, airway management, use of TEE, ensuring hemodynamic stability and adequate postoperative analgesia.

Material and Method

After the approval of Local Ethics Committee, between 2012-2017 years, American Society of Anesthesiology (ASA) 1-3, a total of 38 pediatric cases between 2 and 18 years of age which were performed for percutaneous closure of atrial and

***Coresponding Author:** Sedat Akbas, Inonu University, Faculty of Medicine, Department of Anesthesiology and Reanimation, Malatya, Turkey
E-mail: sedat.akbas@inonu.edu.tr

ventricular septal defects were included in the study. Cases more than 18 years old, severe respiratory disease, severe pulmonary hypertension, immunodeficiency, anesthetic drug allergy and need for conventional surgery were excluded.

Age, gender, height, weight, body mass index (BMI), ASA scores, mallampati scores, laboratory values, anesthesia time (the time from induction of anesthesia to tracheal extubation), procedure time (the time from initiation of vascular cannulation by cardiologist to removal of the catheters), ASD/VSD diameters, comorbidities, preoperative symptoms, heart rate before induction (baseline) and postoperative, noninvasive blood pressure (NIBP), peripheral oxygen saturation (spO_2), electrocardiography (ECG), minute respiration rate, value of end-tidal carbon dioxide ($EtCO_2$), complications during and after procedure, intensive care stay and discharge times of all cases were recorded.

Preanesthetic evaluation was performed 2 or 3 days before the procedure for all patients. Before the procedure, following a fasting periods ranging 4-8 hours depending on the ages of cases, premedication was administered with oral midazolam 0.5 mg.kg-1 with a maximum dose of 15 mg and then cases were taken to the catheter laboratory. Standard monitorisation was applied to all cases as 5-leads electrocardiogram, non-invasive blood pressure, pulse oximeter and capnography. After the femoral arterial catheterization was performed, also invasive arterial blood pressure was monitored. General anesthesia induction was performed with intravenous anesthetics or 8 % sevoflurane inhalation in 50 % oxygen-air mixture. TEE monitoring was performed by the same pediatric cardiologist throughout the procedure after anesthesia induction and orotracheal intubation.

Statistical Evaluation

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 18.0 (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 38 patients (47.4%; 18 males, 52.6%; 20 females) with a mean age of 7.71 ± 3.57 years (range: 2-18 years) who performed for pediatric patients undergoing percutaneous closure of atrial and ventricular septal defects in catheter laboratory. ASA classification of the cases were found II for 94.7% (36 patients) and III for 5.3% (36 cases). All of the cases were found to be II for Mallampati score. Demographic data is presented in Table I.

Table 1. Demographic data

	ASD (n=30)		VSD (n=8)	
	Range	**Mean ± std**	**Range**	**Mean ± std**
Age, years	3-16	7.76 ± 3.70	2-12	7.33 ± 3.66
Weight, kg	7-86	28.36 ± 17.62	7-86	26.83 ± 14.93
Sex, male/female	12/18	-	6/2	-
ASA class II/III	28/2	-	8/0	-

ASA: American Society of Anesthesiology, ASD: Atrial Septal Defect, std: Standard Deviation, VSD: Venricular Septal Defect

Of the cases; 78.4 % (30 cases) diagnosed ASD, 21.6 % (8 cases) diagnosed VSD were operated. There were pulmonary stenosis (7.9 %; 3 cases) and acute rheumatic fever (2.6 %; 1 case). 39.5 % of the cases (15 cases) had preoperative symptom. No clubbing and cyanosis were detected in any of the cases. The most common presenting symptoms of the cases were fatigue (2.6 %; 1 case), fainting and bruising (2.6 %; 1 case), chest pain (21.1 %; 8 cases), palpitation (10.5 %; 4 cases), murmur (55.3 %; 21 cases). There were parental consanguinity (21.1 %; 8 cases) and heart disease in their family (15.8 %; 6 cases).

Mean defect size was 11.60 ± 6.27 mm for ASD and 6.00 ± 4.64 mm for VSD. Mean anesthesia time was 71.33 ± 22.77 minutes for ASD and 85.83 ± 26.91 minutes for VSD. Mean procedure time was 56.00 ± 20.56 minutes and 69.16 ± 28.70 minutes for VSD. In terms of intensive care unit stay; (5.3 %; 2 cases) were followed for 1 day and (92.1 %; 35 cases) for 2 days. Mean ICU time was 1.9 ± 0.40 days for ASD and 1.83 ± 0.40 days for VSD. Cases were discharged from the hospital after 1 day (2.6 %; 1 case), 2 days (26.3 %; 10 cases), 3 days (68.4 %; 26 cases) and 4 days (2.6 %; 1 case). Mean discharging time was 2.76 ± 0.67 days for ASD and 2.66 ± 0.51 days for VSD. Procedure data is presented in Table II.

Table 2. Procedure Data

	ASD (n=30)		VSD (n=8)	
	Range	**Mean ± std**	**Range**	**Mean ± std**
Defect size, mm	1-28	11.60 ± 6.27	2-15	6.00 ± 4.64
Anesthesia time, min	30-130	71.33 ± 22.77	60-130	85.83 ± 26.91
Procedure time, min	20-120	56.00 ± 20.56	40-115	69.16 ± 28.70
ICU stay, day	0-2	1.9 ± 0.40	1-2	1.83±0.40
Discharging, day	1-5	2.76 ± 0.67	2-3	2.66±0.51

ASD: Atrial Septal Defect, ICU: Intensive Care Unit, std: Standard Deviation, VSD: Venricular Septal Defect

Premedication was performed for 94.7 % (36 cases) after taking the cases to the angiography laboratory. Anesthesia induction was performed with propofol (94.7 %; 36 cases) and pentothal sodium (5.3 %; 2 cases) as anesthetic agent, fentanyl (63.2 %; 24 cases) and remifentanyl (36.8 %; 14 cases) as analgesic agent, rocuronium (65.8 %; 25 cases) and vecuronium (34.2 %; 13 cases) as neuromuscular blockade. Orotracheal intubation was preferred and there was no difficult intubation for the cases. Sevoflurane was used for anesthesia maintenance peroperatively.

Mean heart rate (Baseline/Postoperative, /min) was 106.76 ± 12.78 / 94.86 ± 11.59 for ASD and 105.83 ± 13.57 / 92.00 ± 12.96. Mean systolic arterial pressure (Baseline/ Postoperative, mmHg) was 108.63 ± 15.62 / 101.43 ± 12.29 for ASD and 109.16 ± 11.58 / 100.50 ± 7.44 for VSD. Mean diastolic arterial pressure (Baseline/ Postoperative, mmHg) was 59.16 ± 15.62 / 57.03 ± 9.85 for ASD and 64.16 ± 9.70 / 100.50 ± 52.50 for VSD. Mean oxygen saturation (Baseline/Postoperative) was 99.36 ± 1.03 ± 99.70 for ASD and 99.66 ± 0.51 / 99.83 ± 0.40 for VSD. Mean End Tidal CO_2 (after induction/ before extubation) was 33.50 ± 2.47 / 34.33 ± 2.45 for ASD and 34.83 ± 2.71 / 34.16 ± 3.65 for VSD. Hemodynamic data is presented in Table III.

Table 2. Hemodynamic Data

	ASD (n=30)		VSD (n=8)	
	Range	**Mean ± std**	**Range**	**Mean ± std**
Heart Rate, /min				
Baseline	85 - 136	106.76 ± 12.78	90 - 130	105.83 ± 13.57
Postoperative	75 - 120	94.86 ± 11.59	80 - 115	92.00 ± 12.96
Systolic Arterial Pressure, mmHg				
Baseline	83 - 155	108.63 ± 15.62	90 - 120	109.16 ±11.58
Postoperative	80 - 135	101.43 ± 12.29	90 - 110	100.50 ± 7.44
Diastolic Arterial Pressure, mmHg				
Baseline	17 - 95	59.16 ± 15.62	50 - 75	64.16 ± 9.70
Postoperative	40 - 80	57.03 ± 9.85	40 - 65	52.50 ± 9.35
Mean Arterial Pressure, mmHg				
Baseline	45 - 105	73.73 ± 13.06	66 - 90	79.16 ± 8.88
Postoperative	60 - 96	70.86 ± 8.96	58 - 76	66.00 ± 6.57
Oxygen Saturation, sPO_2				
Baseline	95 - 100	99.36 ± 1.03	99 - 100	99.66 ± 0.51
Postoperative	98 - 100	99.70 ± 0.59	99 - 100	99.83 ± 0.40
End Tidal CO_2				
After Induction	30 - 40	33.50 ± 2.47	32 - 38	34.83 ± 2.71
Before Extubation	31 - 39	34.33 ± 2.45	31 - 41	34.16 ± 3.65

ASD: Atrial Septal Defect, CO_2: Carbon Dioxide, std: Standard Deviation, VSD: Venricular Septal Defect

None of the cases had hemodynamic instability and did not require ephedrine, esmolol or nitroglycerin. TEE was used in 86.8 % (33 cases) of the cases. Complications developed for 1 case peroperatively and for 2 cases postoperatively. IV paracetamol and IV tramadol were preferred in (84.2 %; 32 cases) and (2.6%; 1 case) of the cases, respectively.

Discussion

Along with technological and medical advances, percutaneous closure of ASD/VSD, which is widely used in pediatric patients, is often preferred because of its many advantages. In these very sensitive procedures, the patient is requested to be immobile and general anesthesia is preferred to maintain hemodynamic stability of the patients [3,4].

Karagöz et al. emphasized in their retrospective studies that pediatric use of TEE in a supine position could be very uncomfortable, might develop pain-induced hemodynamic instability due to TEE, and also general anesthesia would be more appropriate in terms of ensuring effective airway management [4]. In this study, it was observed that 86.8 % of the cases required TEE and similarly, general anesthesia was preferred considering the problems caused by the use of TEE. Sedation was not preferred because of possibility of extension of the procedure time, TEE which is uncomfortable and painful and especially the difficulties of airway management and hemodynamic stability in children.

Laussen et al. specified in their retrospective study that they started the procedure with sedation but changed the management of anesthesia depending on development of hemodynamic complications and passed to general anesthesia, inotropic agents or pacing were required in almost half of the cases [7]. In many similar studies, sedation was not sufficient practice and general anesthesia was preferred [1,4,7]. In this study, it was observed that general anesthesia was preferred in order to maintain the hemodynamic stability especially for closure of ASD/VSD by transcatheter technique.

Oklu et al. showed in prospective, randomized and blinded study that propofol infusion significantly reduced the systemic mean arterial pressure, systemic vascular resistance in patients with cardiac shunt and increased systemic blood flow. They indicated that ketamine significantly increased the systemic mean arterial pressure but did not alter pulmonary mean arterial pressure, systemic and pulmonary vascular resistance, increased in right-left shunting in children with intracardiac shunts, decreased in pulmonary blood flow and thus might cause arterial desaturation [3]. Karagöz et al. reported in their retrospective study; there was no significant complication associated with propofol and fentanyl anesthesia and they could be safely applied [4]. In this study, it was observed that; fentanyl was preferred for analgesia with propofol (94.7 % of the cases) in anesthesia induction, hemodynamic complications developed in only 3 cases and ketamine was not preferred in none of the cases. In anesthesia induction, it was often selected the triple combination as propofol-fentanyl-rocuronium which had minimum effects of hemodynamic stability. And for anesthesia maintenance, sevoflurane was used between 1-1.5 MAC to ensure adequate depth of anesthesia and there was no need for additional anesthetic agent. It was observed that bispectral index (BIS) monitorisation was unfortunately not used in catheter laboratory, but we believe BIS monitorisation will be useful for these sensitive procedures.

With a different perspective, Kogan et al. reported in their prospective study, sedation with propofol-ketamine combination was safe and alternative to general anesthesia [8]. In this study; it was considered sevoflurane inhalation was preferred in anesthesia maintenance. It was considered that ketamine was not appropriate option because it significantly increased the systemic mean arterial pressure. On the other hand, sedation was not safe in terms of using TEE which is uncomfortable for the pediatric patients.

Joshi et al. stated in their prospective study, the heart rate with dexmedetomidine was significantly lower, but the recovery time was more of that and the use of dexmedetomidine-ketamine combination was safe and alternative (9). Despite that Riveros et al. in which examined the effects of dexmedetomidine use in their controlled study reported that dexmedetomidine infusion had no benefit to maintain hemodynamic stability or reduce agitation in pediatric patients undergoing cardiac catheterization procedures when it was compared with other general anesthesia techniques [10]. In this study, it was observed dexmedetomidine was not preferred because of only indication for use in intensive care units and no difference between other anesthetic agents.

Soliman et al. reported in their double-blind randomized study that there was an increase of analgesic consumption and recovery time in propofol group. If sedation was preferred in cardiac catheterization, ketofol had more advantages in terms of rapid onset of sedation, fast recovery time and low incidence of nausea and vomiting [11]. In multi-centered studies of Grunwell et al indicated that almost all of the procedures was successfully completed, increased the use of anticholinergic and benzodiazepines. They showed the risk factors related to ASA scores were III and up, comorbid diseases and long procedure time [12]. Toda et al. reported that there was no statistical correlation between the consumptions of anesthetic and analgesic drugs such as fentanyl and sevoflurane with vital findings, but the decrease in heart rate when the amount of fentanyl exceeded 4 $\mu g.kg^{-1}.h^{-1}$ [13]. In our study, it was observed sevoflurane was used in anesthesia maintenance, fentanyl was preferred for analgesia not exceeding the dose of 2 $\mu g.kg^{-1}.h^{-1}$ and there was no need for additional anesthetic agent. On the other hand, IV paracetamol was sufficient for postoperative analgesia in almost all cases.

Jalal et al. in which investigated the long-term complications reported that using of occlusive device had evidence of efficacy and safety, a lot of advantages and minimal complications for short-term, the most severe complication of long-term effects were thrombosis and cardiac erosion and the most common was atrial arrhythmia [14]. In this study, it was obtained similar results regarding short-term effects and there was no complications related to occluder device.

Jerome et al. reported in editorial letter it would be more appropriate the presence of anesthetists specialized in pediatric cardiology in pediatric cardiac catheterization procedures [15]. In our study, it was regarded that there was no specialist in the field of pediatric cardiology. However, anesthesia management were found to be better because of preferred for general anesthesia, decreased complications and maintained hemodynamic stability.

Anesthetists should also check adequate facemasks, intubating stylet, tube-changer or gum elastic bougie, laryngeal mask airways, videolaryngoscopy, rigid laryngoscopic blades of alternative design or size, fiberoptic-guided intubation and aspirator for unexpected difficult airway management, all monitorisation devices, emergency drugs, defibrillator, BIS and TOF devices in catheter laboratory [16].

Study Limitations

It was observed there was no record of pulmonary artery pressure of the pediatric patients. But we know that intracardiac pressures are being checked by pediatric cardiologists which is very important for these procedures and especially for anesthesia management. Hemodynamic changes should be recorded in more detail during the closure of ASD/VSD. Also there is a need for prospective studies in order to compare the reliability of general anesthesia and sedation/analgesia applications in these procedures.

Conclusion

In pediatric cardiac catheterization procedures, different preferences of anesthesia management are applied. Anesthetic drug preferences will be important in terms of anesthesia management, procedure time, knowledge of pediatrists and anesthetists if sedation/analgesia is preferred. Although it has been reported that sedation can be safely applied, we believe that general anesthesia will be safer due to reasons such as airway management, patients' immobility, problems of using TEE, maintenance of hemodynamic stability. Many anesthetic drugs and combinations have been used for these procedures in different anesthetic applications. Either sedation/analgesia or general anesthesia are applied, strict hemodynamic follow-up will be more important. Along with knowledge and experience being important, it will be gained importance to have specialist anesthetists for unusual complications related to pediatric catheterization procedures.

Competing interests
The authors declare that they have no competing interest.
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