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Anesthesia Management of Pediatric Heart Catheterization Laboratory

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Abstract

Cardiac catheterization operations are often performed to view the heart and vascular system with an X-ray device by providing access through the femoral, axillary, jugular or other large artery and vein. In the pediatric age group, the diagnosis of congenital heart anomaly, its treatment is very important in terms of surgical decision and timing. With the contribution of technological developments, its use has become widespread and experienced anesthesiologists have more duties. The cardiologist, cardiovascular surgeon, and anesthesiologist performing the intervention should work in coordination and cooperation. It is very important for the success of the procedure that the anesthesiologist is familiar with the environment and has sufficient knowledge, skills and experience to cope with the problems that may arise.

Keywords: Congenital heart disease; Catheter angio laboratory; Pediatric anesthesia; Pediatric cardiology

Introduction

Cardiac catheterization is being described as a process which is made by dispatching catheter inside the heart, usually from femoral, axillary, jugular area, or another large artery and/or vein. It is used for evaluation of cardiovascular structural anatomy and hemodynamic functions. Catheterization laboratories are special and semi-sterile places which enable pressure measurement being made accurately and are equipped with X-ray devices to view the position of catheters and the distribution of the given radiopaque materials. Although the first studies related to scanning of catheters being sent from the femoral areas started at 1945, the first notice was made by Bing with the diagnosis of tetralogy of fallot of a congenital cyanotic cardiac [1]. The first execution of anesthesia during catheterization is reported with the usage of meperidine, promethazine, and chlorpromazine which are traditionally frequently used in that period, in 1958 [2].

Cardiac angiography operations are still being used as a golden standard final diagnosis vehicle albeit the improvements in transthoracic/transesophageal echocardiography, computerized tomography, and imaging techniques in cardiac Magnetic Resonance (MR). Cardiac catheterization laboratories are fields that are perpetually flourishing and expanding, nowadays, apart from the diagnostic evaluation and hemodynamic measurements, therapeutic operations are being done often. Especially, the extent of cardiac catheterization in pediatric patients changes into being therapeutic interference rather than a tool of diagnosis [3,4].

Most of the kids who are put into process in cardiac catheterization laboratories are under the age of 1 and in high risk of cardiac arrest [5]. Approximately 1/3 of the pediatric cases which experience cardiac arrest which related to anesthesia in perioperative phase were congenital cardiac and 17% of the arrest occurred during heart catheterization is being reported [6].

Catheterization labs, because of their special conditions, have settings which block the access to the patient, offer limited functional space, are physically isolated from the additional anesthesia sources and compel the urgent resuscitation conditions. Therefore, especially medicaments which can be used in urgent conditions, additional airway instruments, spare tubes, mask and laryngeal masks, respirators, and difficult intubation equipment must be in an easily accessible place.

Our Aims in Catheterization Laboratories and Determinant Factors

During the sedation and anesthesia which are implemented on kids with congenital heart condition, heart chambers and pressure on big veins and oxygen saturations affect the kid's response to the anesthetic medication. For that reason, parameters given below which surely affect both pressures and oxygen saturations must be known in detail and managed by the individuals who implement anesthesia.

- Places, functions, and sizes of the shunts during heart catheterization
- Pulmonic and systemic vascular resistances
- Sizes, numbers, and functions of heart chambers
- Valvular anatomy and functions
- Systemic/pulmonic artery anatomy related to old surgical and changes in its physiology
- Coronary artery anatomy

- Planned vascular entryways and process plan
- Adscititious or congenital other additional anatomic differences

Performance of measurement and operation in normal room air is what is ideal during the process. However, if additional oxygen is being applied, its effect on the applied measurement and evaluation must be taken into consideration. Due to heart pump, while the necessity of oxygen is transmitted to all tissues with systemic blood veins, comprised carbon dioxide in consequence of metabolism is thrown out by sending away from the tissues with the pulmonary circulation. Pulmonic (QP) and systemic flow (QS) are equal in normal individuals who does not have shunt and with fick principle, QS/QP ratio is stated as 1/1=1. In shunt flaws, this ratio changes related to shunt's size and physiology. Pulmonary Vascular Resistance (PVR) and Systemic Vascular Resistance (SVR) are calculated with Poiseuille equation, whereas oxygen consumption is calculated with the usage of La Farge equation in compliance with heart rate, sex, and age (between 3 and 40) as shown in Table 1. Yet, in kids who are younger than 3 years and have congenital heart condition, this situation is less trustworthy [7]. Still, under the general anesthesia, Fick cardiac index is valid for kids who have normal cardiac physiology and anatomy [8]. Circulation parameters, shunt ratios, and resistance measurements guide to the next medical measurements and surgical operations when they are considered altogether.

Variable	Equation	Normal
Oxygen consumption	VO2=(CO x CaO2)–(CO x CvO2)	Age, heart rate, gender
Flow		
Pulmonary	QP=VO2/(SPVO2-SPAO2) x Hb x 1.36 x 10	3,5-5 (L.min-1.m-2)
Systemic	QS=VO2/(SAOO2–SMVO2) x Hb x 1.36 x 10	3,5-5 (L.min-1.m-2)
Şant Oranı	QP(SAOO2–SMVO2)/(SPVO2-SPAO2)	01-Jan
Direnç		(Woods unit)
Pulmonary Systemic	PVR=(PAP–LAP)/OP SVR=(AoP–RAP)/ QS	8-10/ 1-3 10-15/15–30

Table 1: Hemodynamic calculations using cardiac catheterization data. VO2: Oxygen Consumption; CO: Cardiac Output; CaO2: Arterial Oxygen Content; CvO2: Venous Oxygen Content; QP: Pulmonary flow; QS: Systemic flow; SO2: Oxygen saturation; PV: Pulmonary Vein; PA: Pulmonary Artery; Ao: Aort; MV: Mixed Venous; PVR: Pulmonary Vascular Resistance; PAP: Pulmonary Artery Pressure; LAP: Left Atrial Pressure; SVR: Systemic Vascular Resistance; AoP: Aortic Pressure; RAP: Right Atrial Pressure.

Basic Pathologies

Cardiac pathologies that are encountered in patient groups who will receive cardiac catheterization may be classified either related to hemodynamic flow as shown in Table 2 or patient's physiologic condition (such as left to right or right to left shunts, mixture creating or obstructive and regurgitant lesions…).

Lesions	Examples
Right-to-left shunt lesions	• Great vessel transposition
	• Tetralogy of Fallot
	• Tricuspid atresia
Left-to-right shunt lesions	• PDA
	• ASD
	• Atrio-Ventricular Septal Defect (AVSD)
	• VSD
Lesions that limit ventricular functions	• Aortic coarctation
	• Aortic stenosis
	• Pulmonary stenosis

Table 2: Classification according to hemodynamic flow.

Shunts are liaisons between intracardiac or systemic-pulmonary circulations. Blood flow's direction, which gets through shunt, depends on the relative pressures around shunt and shunt's own resistance. Its physiologic effect to cardiovascular system is related to the size and direction. In left-right shunt, pathophysiology which directed blood flow through the lungs and PVR is lower than SVR. e.g., Atrial Septal Defect (ASD), Ventricular Septal Defect (VSD), Patent Ductus Arteriosus (PDA). Chronically raising pulmonary blood flow may cause eisenmenger syndrome and pulmonary hypertension due to reverseless raise in PVR. In right-left shunt, on the contrary, PVR or Right Ventricular Outflow Tract (RVOT) passes SVR, and pulmonary blood flow is decreased. Systemic circulation takes a mix of deoxygenated blood with the shunt and patient becomes clinically cyanotic. Persistent pulmonary hypertension can be seen even in neonatal phase in right-left shunt and Eisenmenger complex related to high PVR. e.g., Pulmonary atresia-VSD, Fallot tetralogy. In this case if hypoxemia, which is so serious that contorts heart function, does not occur, systemic perfusion is generally normal.

In complex lesions, oxygenated and deoxygenated blood circulates fully mixed in pulmonary and systemic systems which are normally parallel working and isolated from each other. e.g., Transposition of Great Arteries (TGA), along with tricuspid atresia with VSD, ASD. Usually, patients have decreased pulmonary blood flow and variable QP/QS ratio, pressure and volume overload are clinically apparent. If PVR surpasses SVR, systemic blood flow dominates the table and pulmonary blood flow decreases dramatically. This causes progressive hypoxia, yet also, well-preserved perfusion pressures. If there is not a timely intervention, progressive circulation desaturates progressively, and organ perfusion starts to get affected by hypoxia. There is an admixture in these lesions at the levels of atrium, ventricle, or arterial veins (with a shunt or PDA).

As to obstructive lesions, because of obstruction or stenosis, ventricular hyperactivity and proximal which try to overcome the area's impedance is the subject of high pressure. Lesion may be innate or acquired. Albeit the muscular hypertrophy, stress of wall of ventricle is generally protected. However, clinical progression ends with myocardium thickened in time, myocardial ischemia, and waned power of spasming. As to tissue perfusion, it is inadequate in distal considering the localization of obstruction area. e.g., Valvular stenosis, aorta coarctation, hypoplastic left heart syndrome. In conclusion, ventricle disfunction loaded left ventricle and ductal dependency are evident.

Regurgitant lesions are rarely first level congenital lesions and they mostly show up in consequence of the advance of congenital cardiac or related operations. Progressive inadequacy of forward flow, a loaded systemic flow, ventricular dilatation, and inadequacy is obvious. e.g., Epstein anomaly.

Patients who have transmission line anomaly are also put into operation in heart catheterization laboratories. This group of patients involves a great population which comprises children age group to geriatric age group. These patients who consulted with different arrythmia types or heart block may be clinically healthy yet, they also may be having distorted left ventricle function or cardiomyopathy or even myocardial infarction. In addition to all these congenital cardiac pathologies, different anatomical, genetic syndromes and comorbidities can be seen in this patient group. A connection between down syndrome (Trisomy 21) and atrioventricular septal defects Rowe et al. [9] is reported in literature. Increased anticholinergic susceptibility Harris et al. [10], cervical vertebra dislocation Moore et al. [11], a large tongue, and tonus increase in laryngopharyngeal muscles may aggravate the anesthesia procedure and operations.

Anesthetist's Role in Heart Catheterization Laboratories and Management of Anesthesia

Each patient and operation must be evaluated in their own perspective as there is no universal anesthesia approach suggestion in heart catheterization laboratories. A great deal of factors affect our anesthesia preference and appliance such as cardiac valve anomaly and pathologies, condition of current shunts, disconnection and anomalies of large artery and vein connections, number and functional situation of heart chambers, ventricular overload and existence of hemodynamic instability, alimentation problems and functions of myocardia and coronary arteries, arrythmias, intervening ailments, general condition and mental problems, family and patient's psychosocial problems. Anesthetists undertakes a job with great risks because of both diagnostic and therapeutic operation success and complications.

Preoperative preliminary consideration and history's careful recording is important in terms of anesthesia and operation success. In addition to routine anesthetic evaluation, congestive heart failure findings must be interrogated, such as especially fatigue history, frequent cyanotic attacks and findings indicates to cardiorespiratory reserve loss, tachypnea, malnutrition, and recurrent respiratory tract infections. Intervening ailments should be excluded. In some patients, treating may be required despite the pulmonary infections rooted from high pulmonary blood flow. This condition requires anesthetist to be more careful and wary against possible complications. Previous surgical and cardiological operations may influence anesthesia plans for the present operation. In the meantime, patient's previous multiple acceptances and procedures may provoke poor patient compliance causing troublesome venous access and psychological trauma. During physical treatment, situations like cachexy, respiration stress, cardiovascular reserve's evaluation must be taken into consideration due to the applicable technique during the premedication or induction. Listening with the existence of rale-rhonchus are warnings for lower respiratory tract infection. As increased airway reactivity and increase of PVR of a patient may end up with the failure of operation in pneumonia table, treatment of the kid should be started with the postpone of the optimal conditions to take the kid into operation. Current cardiac medicaments of the patient must be interrogated and evaluated in terms of their interactions with anesthetic agents and appliances as shown in Table 3.

Cardiac drugs	Potential impacts	Measures
Diuretics	Hypovolemia/ Hypokalemia	Should be discontinued in the preoperative period
	Increase in muscle relaxant effect	
Antiarrhythmics	Proarrhythmic effect in the presence of inotropic	Checking the electrolyte status
	Electrolyte imbalance	If there is a defect, it must be corrected.
		Proarrhythmic agents should be avoided.
α 2- Agonists	Perioperative tremor decreases	Appropriate monitoring
	The risk of ischemia is reduced	Continuing treatment in the perioperative period.
	The need for analgesia decreases	
ACE inhibitors	Hypotension in general anesthesia induction	Dose can be reduced/ skipped
		Serious vagomimetic effect.
β-Blockers	Risk of tachyarrhythmia with discontinuation of therapy	Continuing treatment in the perioperative period.
	Hypotension with volatile anesthetics	
	Decreased inotropic response	
Calcium channel blockers	There may be an increase in the negative inotropic and	Continuing treatment in the perioperative period.
	chronotropic effects of volatile anesthetics.	

Table 3: Possible effects of cardiac drugs.

Examination and evaluation of laboratories must be certainly made yet, unnecessary tests must be reduced to the minimum. Due to permissible blood loss and transfusion need, complete blood cell count is required. During the complete blood cell count, it is a warning in terms of rise of hemoglobin and hematocrit values (0,60 and above), chronicity and greatness of hypoxemia, risk of hyperviscosity and related end organ damage is increased in patient [12,13]. In this case, patient's hydration or heparin infusion may be considered before the operation. Congenital cardiac diagnose and clinic should be evaluated with the measurement of patient's oxygen saturation. Diuretics must be ended to ensure hemodynamic stability before the operation, serum electrolyte and kidney functions must be investigated. Kids who are prone to have deterioration in their blood urea nitrogen and creatinine in laboratory, as they possess a risk of worse deterioration during the process with the effect of contrast agent, n-acetylcysteine treatment must be considered before process.

All sedative agents can be used for premedication. Despite the many research made previously, there is not a universal convincing premedication suggestion [14-16]. Sedatives from Benzodiazepine class are often preferred; midazolam is used more often compared to others. (e.g., oral midazolam 0,5 mg/kg) necessity of premedication, underlying medical condition, duration of process, anesthesia method and induction type, parent and kid's psychological situation, existence of separation from the parent anxiety, is determinant. However, it is not suggested for kids who are younger than 6 months, cyanotic and dyspneic, and has a grave general condition. In monitoring and follow-up, ASA suggests using routine operation room monitorization techniques (EKG, track of non-invasive blood pressure, SpO2 and EtCO2). However, during electrophysiological studies and unpredictable blood pressure changes, invasive arterial track can be made [17]. Hypothermia is a serious problem for premature and low birth weight babies, body temperature track would be beneficial. Again, in newborns, blood glucose level track is important due to hypoglycemia risk [18]. Patients with serious heart failure and clinic perfusion disorder or who are hypoxic, must receive required replacements with checking their arterial blood gas [19].

In the management of anesthesia, general anesthesia ensures great advantages with the patient satisfaction related to control of anaesthetic depth, reflex and loss of response to the painful stimulus, assurance of full hypokinesia, airway security, reduced existence of airway occlusion or secretion problems, EtCO2 tracking, patient not having anxiety of vigil, quality tolerance of patient or patient's comfort psychologically, compared to sedation. However, changes in shunt functions, decrease of SVR with the positive pressure ventilation, vasodilatation and decrease in venous rotation, decline of oxygen consummation with the decline in metabolic rate, because of hemodynamic factors, may affect the present measurements [20]. During recovery, providing vascular entryway hemostasis may sometimes be a serious problem. Noticing containment of every modality and optimizing the circumstances in the best way possible are important. Ultimately, anesthesia management for each patient must be handled separately and effects of used model must be noticed. Physiologic circumstances must be provided in current conditions or closest optimal conditions must be tried to form. If general anesthesia is being used, for instance, placing the patient 0, 21 FiO2 in oxygen wielding, patient should be held in a physiologic space and at normal ph. Control PaCO2 track, with using ventilator strategy which restricts peak inspiratory pressure, while avoiding high PEEP, applying precautions which protects intravascular volume would be accurate.

Benzodiazepines, in the anesthesia management with sedoanalgesia, ketamine, propofol and opioids are being used combined often with two or more pharmacological agents. Being awaken is important because of the side effects of medications and using divided because titrated doses. Ketamine may increase heart rate, blood pressure and PVR. As to propofol, especially during induction, hypotension incidence risk is high. Sometimes, in shunts with high sensitivity, with the rise of oxygen saturation [21], diffusions which state hypotension are present.

As induction technique is important, inhalation or parenteral techniques may be chosen related to cardiac function condition, premedication rate and intravenous way condition, in general anesthesia.

İnhalation induction is preferred in patients such as babies and little kids or patients with troublesome venous access. Sevoflurane is especially appropriate with low resolution ratio and confidential hemodynamic profile. Patients with right-left shunt have prolonged inhalation induction as arterial blood bypasses lungs and dilutes with mixed venous blood. As to patients with left-right shunt, induction duration is decreased and anesthetic concentration in blood increases because of the afresh circulation of blood with partly saturated anesthetic agent.

In intravenous agents, compensating the shunt effect with the increase of concentration bears the risk of overdose. Opioids are generally intravenous agents which are used frequently in combination with other agents. In patients with right-left shunt, some of the anesthetics bypass pulmonary stage to reach the brain, and they show a rapider induction. Slower induction is observed in left-right shunt patients due to the diluted agent with afresh flow of the contrary blood. Hemodynamic stability must be provided in propofol usage. In cyanotic patients, as ketamine, with SVR and increase of cardiac output, would provide a decrease in the amount of right-left shunt, it becomes prominent in pharmacological preference.

Usage of neuromuscular blockage stops the patient movement and makes it easier to put sensitive device by reducing the cardiac tissues' slip during ventilation. After the neuromuscular blockage, Intermittent Positive Pressure Ventilation (IPPV), especially in patients who have direct connection between the left and right side of heart, reduces the risk of air embolism [22]. e.g., ASD, VSD, and Patent Foramen Ovale (PFO). However, as there is a truth like IPPV will influence the data obtained, it should be balanced. Apart from that, it must be mentioned that systemic venous reduces the rotation when intravascular volume is decreased. Specifically, blood flow is usually passive and dependent on inadequate preload in patients with single ventricle physiology. Desaturation in these patients, may indicate to imperiling pulmonary blood flow. Limitation of peak inspiratory pressure, avoiding high Positive End-Expiratory Pressure (PEEP), protection of pulmonary blood flow, optimization of oxygen delivery, and protection of intravascular volume are the fundamental principles with patients under general anesthesia.

Pulmonary Hypertension (PH) and PH crisis increases the risk of sudden cardiac arrest and death risk, as it is an important problem, in management of anesthesia [23]. With general anesthesia or sedation techniques or ketamine, propofol, etomidate, or mixture of inhalation agents, during the catheterization of PH patients, a significant difference was not observed in terms of complications [24]. However, despite the concerns of rise of PVR, there are issues about ketamine being safer [25].

Patients in postoperative care, after the sedation or general anesthesia, should be observed for vital signs with the reference to recovery guides. All entryways must be observed in terms of bleeding signs. If arterial access is used, it must be observed regarding distal pulse, perfusion condition, arterial spasm, or thrombosis. Many outpatients can be discharged after the 4-6 hours of process, when they are awake, comfortable, and mobile. Serious hemodynamic problemed patients may require follow up and cardiorespiratory support.

Applied Procedures and Encountered Complications

New technological developments and equipment have changed the extent of pediatric heart catheterization and started to change its usage area to therapeutic side rather than diagnosis [3,4]. Thanks to cardiac scanning and additional apparats, it offers options of limiting the bigger surgical operation while reducing surgical risks, postponing the possible surgical process, or treating with interventional operation.

In procedures of diagnosis and identification, most commonly with the right-side arteria femoralis and/or the approach of vein cannulization and while screening with the passing of catheters to right and left heart, diagnosis and identification is made [26]. Indication of procedural process or operation to be held is held with the pressure measurement and blood sampling from the heart chambers or great vascular tissues, oxygen saturation measurement, detection of places and existence of shunts, consummation of oxygen and various calculations. However, in patients with impossible femoral area cannulization, brachial and jugular area procedures can be made. Shim and their friends reported that with transhepatic procedure, access to right heart can be made successfully in patients without a vascular entryway [27].

In interventional procedures, apart from the therapeutic operations which remove surgical necessity completely, subsidiary of surgical operations can be made. First interventional heart catheterization was made by Rubio-Alvarez and Limon-Laisen for pulmonary valve stenosis in 1953 [28]. While the very first atrioseptostomy trial made by rashkind Rubio-Alvarez et al. [29] who invented the current type balloon, Rashkind et al. [30] developed PDA tampon and closed the ductus successfully in 1967. With the development of occlusion and septal occluders, closing ASD, VSD, PDA and fenestrations had become possible. An ASD being tapped without surgery with the usage of double septal occluders was reported for the first time in 1976 [31].

Although interventional operations provided great advantages to the patients, they carry important complications concomitantly. While complication ratios after the tapping of transcatheter ASD are approximately 5%, hypotension in 40% and arrythmia in 28,5% of cases is reported in tapping of VSD [32]. First coil was released in 1967 and was used in a tapping of PDA. Intravascular spring coil spirals are used frequently in PDA, aortopulmonary collaterals, coronary artery fistula and closing of some arteriovenous malformation nowadays. In operations of embolization, especially in big defects, permanent residual shunt (5%-10%) or passage to coilin pulmonary artery or systemic veins, unwanted embolization complications can be seen [33]. Balloon expansion operation was used by kan and their friends in pediatric age group [34]. This technique was accepted quickly for the expansion of a few main vein apart from the aorta, mitral and tricuspid valves. Turgescing of balloon can cause severe hypotension and vagal bradycardia as blocking the circulation, in all these positions. Deflating the balloon is the definitive treatment method, yet solution is not always urgent. Pulmonary valvotomy balloon dilatation, especially in right ventricle disfunction with>40 mmHg peak gradient or cyanosis conditions, is the preferred treatment [35]. Among its complications, formation of mild and nonprogressive pulmonic regurgitation, exit way rupture and valve avulsion or perforation in most cases, take place. Mitral valvotomies, ones with surgical contraindication, ones with much expectation of problem in repeated surgery, ones with unfavorable anatomy, old and pregnant patients, or young patients with favorable anatomy [36], are the alternatives of surgery and are promising for short- and long-term consequences. Hemopericardium (0,1%–12%), air embolism (0,5-5%), and mitral regurgitation which rarely causes pulmonary edema are concerning complications [37]. In aortic stenosis, all lesions including congenital, can be candidates of percutaneous balloon valvotomy. Vasodilators and beta-adrenergic receptor blockers may be required for over distention of left ventricle and decrease of tachycardia during the process, in management of anesthesia. Acute aorta regurgitation (1%-6%) related to arterial injury, hemorrhage, ventricular arrhythmias, endocarditis, valve leaflet perforation is among the complications of process and there are issues which report at least 20-25% one serious complication in the first 24 hours [38]. Patients with congenital or coarctation of aorta after surgery can be treated successfully with balloon dilatation with or without stent. However, being on alert for circulatory failure, aorta dissection or rupture, aneurysm, cardiac tamponade, hemothorax, coronary artery blockage, and myocardial infarction, restenosis [39,40] kind of serious complications is required. Angioplasty balloon dilatation with or without stent can be made in the case of pulmonary artery stenosis. Complications in aortic stenosis can be also seen similarly in here. As for conditions in which interventional operations can complete surgery, fontan or patients with single ventricle who undergone full cavopulmonary connection can be examples. Surgical mortality and morbidity can be reduced by leaving a fenestration which brings blood to pulmonary arteries from inferior vena cava in duct. Cardiac arrest and arrythmia risk are high in this process in terms of patient's current pathological lesion related to acute heart failure, cyanosis, severe acidosis, circulation, and perfusion disorder.

Electrophysiologic ablation studies made in cardiac catheterization laboratories offers optimal treatment options to define arrythmias' mechanism, root, and pathway. Arrythmias are reproduced afresh with timed electric impulses, under the controlled conditions. Accurate anesthesia method should be chosen by experienced anesthetics as anesthetic agents used during the process will influence the heart rate. It should not be forgotten that all the inhalation agents would pressure heart conduction system [41]. Most of the intravenous induction agents has very little or no effect on cardiac conduction system. For that reason, intravenous anesthesia is an agent, especially preferred propofol. A low ratio like 5% in complications, atrioventricular full block (1%), pericardial effusion (1%-9%), and atrioesophageal fistula (1%) are reported as the ones seen the most common [42].

Permanent pacemakers and Implantable Cardiac Defibrillators (ICD) can be implanted in cardiac catheterization units. In both devices' implantation, electrodes are placed in heart chambers as a transvenous and combined with a main generator tunneled under skin. As these operations may be done under local anesthesia, ones who require repetitive operation, mental problemed people, and kids generally need anesthesia. Detailed and close monitorization is the suggested screening method in these patients during anesthesia.

In addition to the mentioned conditions, excluding interventional operations and catheter manipulations, complications which caused by basic lesions, other problems during the process are imaging equipment fault, risk of infection and contamination, complications of airway, medicament reactions, cerebral hypoperfusion, thrombosis, liver and renal hypoperfusion.

Conclusion

Diagnostic and interventional cardiac catheterization suit is a place which is open to rapid technologic developments, improves itself continuously, and anesthetic needs more experience and knowledge to conduct the patient outside the limits of operation room or intensive care unit. During the cardiac lesion pathophysiology and catheterization, operation's clinical consequences must be understood unambivalently. Patients, from premature newborns to fragile geriatric population, are scattered on a great scale. In these operations which are mostly interventional lately, appropriate anesthesia management of cardiovascular scanning should be done by adequately educated and supported anesthetics. More than one anesthesia technique and medicament options are proved to be successful. Anesthetics who can work in accordance with interventional cardiology and cardiothoracic surgery, who are aware of the emergent hardships, professional in coroner cardiac, can handle the possible complications in this tough suit, are gradually needed more in this special patient population.

References

1. Bing RJ, Vandam LD, Gray FD (1947) Physiological studies in congenital heart disease. Bull Johns Hopkins Hospital 80: 107-20.
2. Smith C, Rowe RD, Vlad P (1958) Sedation of children for cardiac catheterization with an ataractic mixture. Can Anaesth Soc J 5: 35-40.
3. Pihkala J, Nykanen D, Freedom RM, Bendon LN (1999) Interventional cardiac catheterization. Pediatr Clin North Am 46: 441-64.
4. Meadows J, Landzberg MJ (2011) Advances in transcatheter interventions in adults with congenital heart disease. Prog Cardiovasc Dis 53: 265-73.
5. Lasa JJ, Alali A, Minard CG, Parekh D, Kutty S et al. (2019) Cardiopulmonary resuscitation in the pediatric cardiac catheterization laboratory: A report from the american heart association's get with the guidelines-resuscitation registry. Pediatr Crit Care Med 20:1040-47.
6. Ramamoorthy C, Haberkern C, Bhananker SM, Karem BD, Karen L et al. (2010) Anesthesia-related cardiac arrest in children with heart disease: Data from the Pediatric Perioperative Cardiac Arrest (POCA) registry. Anesth Analg 110: 1376-82.
7. Rutledge J, Bush A, Shekerdemian L, Neick IS et al. (2010) Validity of the LaFarge equation for estimation of oxygen consumption in ventilated children with congenital heart disease younger than 3 years--a revisit. Am Heart J 160: 109-14.
8. Seckeler MD, Hirsch R, Beekman RH, Bryam H, Gldestin et al. (2014) Validation of cardiac output using real-time measurement of oxygen consumption during cardiac catheterization in children under 3 years of age. Congenit Heart Dis 9: 307-15.
9. Rowe RD, Uchida IA (1961) Cardiac malformation in mongolism: A prospective study of 184 mongoloid children. Am J Med 31: 726-35.
10. Harris WS, Goodman RM (1968) Hyper-reactivity to atropine in Down's syndrome. N Engl J Med 279: 407-10.
11. Moore RA, McNicholas KW, Warran SP (1987) Atlantoaxial subluxation with symptomatic spinal cord compression in a child with Down's syndrome. Anesth Analg 66: 89-90.
12. Phornphutkul C, Rosenthal A, Nadas AS (1973) Cerebrovascular accidents in infants and children with cyanotic congenital heart disease. Am J Cardiol 32: 329-34.
13. Gordon RJ, Ravin MB (1978) Rheology and anesthesiology. Anesth Analg 57: 252-61.
14. Hensley FA (1990) Premedication for children with congenital heart disease--beneficial or harmful. J Cardiothorac Anesth 4: 423-4.

15. Bailey PL, Pace NL, Ashburn MAA, Moll JWB, East KA et al. (1990) Frequent hypoxemia and apnea after sedation with midazolam and fentanyl. Anesthesiology 73: 826-30.

16. DeBock TL, Davis PJ, Tome J, Petrilli R, Siewers RD et al. (1990) Effect of premedication on arterial oxygen saturation in children with congenital heart disease. J Cardiothorac Anesth 4: 425-9.

17. Laussen PC, Hansen DD, Perry SB (1995) Transcatheter closure of ventricular septal defects: Hemodynamic Instability and Anesthetic Management. Anesth Analg 80: 1076-82.

18. Benzing G, Schubert W, Hug G (1964) Simultaneous hypoglycemia and acute congestive heart failure. Circulation 40: 209-16.

19. Bove EL, Behrendt DM (1980) Open-heart surgery in the first week of life. Ann Thorac Surg 29: 130-4.

20. Matsumoto D, Shinke T, Nakamura T, Shite J, Li J (2013) Optical coherence tomography and histopathological assessment of delayed arterial healing after drug-eluting stent implant in a pig coronary model. Int J Cardiol 170: 152-9.

21. Williams GD, Jones TK, Hanson KA, Morray (1999) The hemodynamic effects of propofol in children with congenital heart disease. Anesth Analg 89: 1411-6.

22. Nicks R (1969) Air embolism in cardiac surgery: Incidence and prophylaxis. Aust N Z J Surg 38: 328-32.

23. Friesen RH, Williams GD (2008) Anesthetic management of children with pulmonary arterial hypertension. Pediatr Anesth 18: 208-16.

24. Carmosino M, Friesen R, Doran A, Ivy DD (2007) Perioperative complications in children with pulmonary hypertension undergoing noncardiac surgery or cardiac catheterization. Anesth Analg 104: 521–527.

25. Williams GD , Maan H , Ramamoorthy C, Kamar K, Braton S et al. (2010) Perioperative complications in children with pulmonary hypertension undergoing general anesthesia with ketamine. Pediatr Anesth 20: 28-37.

26. Williams GD, Friesen RH (2012) Administration of ketamine to children with pulmonary hypertension is safe: Pro-con debate: pro argument. Pediatr Anesth 22: 1042-52.

27. Jonas RA (1994) Indications and timing for the bidirectional glenn shunt versus the fenestrated Fontan circulation. J Thorac Cardiovasc Surg 108: 522-4.

28. Shim D, Lloyd TR, Cho KJ, Morrehead CP, Beckmenll RH et al. (1995) Transhepatic cardiac catheterization in children. Evaluation of efficacy and safety. Circulation 92: 1526-30.

29. Rubio-Alvarez V, Limon R, Soni J (1953) Intracardiac valvulotomy by means of a catheter. Arch Inst Cardiol 23:183-92.

30. Rashkind WJ, Miller WW. Creation of an atrial septal defect without thoracotomy. A palliative approach to complete transposition of the great arteries. JAMA 196: 991-2.

31. Porstmann W, Wierny L, Warnke H (1967) The closure of the patent ductus arteriosus without thoractomy. (preliminary report). Thoraxchir Vask Chir. 15: 199-203.

32. King TD, Thompson SL, Steiner C (1976) Secundum atrial septal defect. Nonoperative closure during cardiac catheterization. JAMA 235: 2506-9.

33. Laussen PC, Hansen DD, Perry SB, Fox ML, Javorski JJ et al. (1995) Transcatheter closure of ventricular septal defects: Hemodynamic instability and anesthetic management. Anesth Analg 80:1076-82.

34. Cambier PA, Kirby WC, Wortham DC (1992) Percutaneous closure of the small (<2.5 mm) patent ductus arteriosus using coil embolization. Am J Cardiol 69: 815-6.

35. Kan JS, White RI Jr, Mitchell SE, Sally E, Timothy J et al. (1982) Percutaneous balloon valvuloplasty: A new method for treating congenital pulmonary-valve stenosis. N Engl J Med 307: 540-2.

36. Mendelsohn AM, Shim D (1998) Inroads in transcatheter therapy for congenital heart disease. J Pediatr 133: 324-33.

37. Lung B, Garbarz E, Michuad P, Mahdhaoui A, Helou S et al. (2000) Percutaneous mitral commissurotomy for restenosis after surgical commissurotomy: Late efficacy and implications for patient selection. J Am Coll Cardiol 35: 1295-302.

38. Herrmann HC, Lima JA, Feldman T (1993) Mechanisms and outcome of severe mitral regurgitation after Inoue balloon valvuloplasty. North american ınoue balloon ınvestigators. J Am Coll Cardiol 22:783-9.

39. Keane JF, Driscoll DJ, Gersony WM, Hayes CJ, Keane JF et al. (1993) Second natural history study of congenital heart defects. Results of treatment of patients with aortic valvar stenosis. Circulation 87: I16-27.

40. Duke C, Qureshi SA (2001) Aortic coarctation and recoarctation: To stent or not to stent?. J Interv Cardiol 14: 283-98.

41. Schaffer MS, Snyder AM, Morrison JE (2000) An assessment of desflurane for use during cardiac electrophysiological study and radiofrequency catheter ablation of supraventricular dysarrhythmias in children. Paediatr Anaesth 10: 155-9.

42. Tsai CF, Tai CT, Hsieh MH, Lin WS, Yu WC et al (2000) Initiation of atrial fibrillation by ectopic beats originating from the superior vena cava: Electrophysiological characteristics and results of radiofrequency ablation. Circulation 102: 67-74.