KALP VE Ddamar CERRAHİSİ ÇALIŞMALARI

Editör: Doç.Dr. Serdar GÜNGÖR

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İÇİNDEKİLER

INCISIONS IN MINIMALLY INVASIVE CARDIAC SURGERY

Abdullah GÜNER[1]

1. INTRODUCTION

As in all surgical branches, a technical evolution is taking place in cardiac surgery. The experience that started with a few cases of minimally invasive valve surgery in the early 1990s has had an impact on almost all cardiac surgeries today. The impact of this change is also seen in recent developments in percutaneous valve technologies. Although conventional surgery including the standard sternotomy approach has proven itself in cardiac surgery, the main reasons for the trend towards minimally invasive surgery are to reduce surgical incisions, to avoid complications of sternotomy, to reduce immunological trauma, to avoid myocardial ischaemia and to ensure pulsatile blood flow during surgery. Achieving these goals requires a multidisciplinary approach and close follow-up of technological development, which is indispensable. When defining minimally invasive in cardiac surgery, the grading of minimally invasive surgery defined by Carpentier and Loulmet is frequently used. Carpentier and Loulmet classify the operation techniques according to incision size and the use of videoscopy (Table 1) (Ritwick et al., 2013).

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Table 1. Carpentier-Loulmet Invasive Surgery Grades

Grade 1	Mini incision (10-12cm) Direct examination
Grade 2	Micro incision (4-6cm) Videoscopy assisted
Grade 3	Micro or port incision (1-2 cm) by videoscopy
Grade 4	Port incision by means of robotic instruments With videoscopy

Source: (Ritwick et al., 2013)

In first-degree operations, smaller incisions (10-12cm) are used instead of median sternotomy or full thoracotomy (20-30cm). At the same time, small additions and modifications to standard surgical instruments help minimally invasive surgery. Thanks to these types of operations, it is easier for the surgeon to transition from traditional sternotomy to minimally invasive methods (Ward, Grossi, & Galloway, 2013).

In second-degree operations, operations are performed with a smaller incision (4-6cm) with the help of videoscopy. In the process of getting used to videoscopy, this process can be accelerated by using a videoscope in cases where conventional sternotomy is performed.

In third-degree operations, a micro or port incision is made (1-2 cm) and the entire surgery is performed with the help of videoscopy.

In the fourth degree operations, unlike the third degree, the surgical procedure is performed by means of a robot. In this case, one surgeon works sterile on the table while the other surgeon works in the robot control unit.

The minimally invasive approach in cardiac surgery includes main elements such as the smallest possible incision, limited or minimal cardiopulmonary perfusion, minimal tissue damage, careful haemostasis and limited use of blood products.

As a result, the main goal of minimally invasive techniques is to provide the same procedural quality with a smaller incision as with conventional sternotomy.

2. PREOPERATIVE EVALUATION

Preoperative evaluation of patients is the most important step in the application of minimally invasive surgical techniques (Ailawadi et al., 2016). In addition to routine preoperative evaluation of the patient, a comprehensive evaluation is essential in terms of suitability for the application of minimally invasive techniques.

The main point in the evaluation is physical examination. In the physical examination, the relevant anatomical regions should be carefully evaluated for the planned surgery, and conditions that may pose an obstacle to minimally invasive surgery (previous right thoracotomy, pectus excavatum deformity, etc.) should be detected preoperatively. Allen test should be performed in patients who will undergo coronary bypass surgery and radial artery graft will be used, and in cases where this test is insufficient, the radial and ulnar arteries should be evaluated with Doppler ultrasonography preoperatively.

Depending on the type of surgical procedure to be performed, single lung ventilation is frequently required in minimally invasive surgeries. In the preoperative evaluation of patients, chest radiography, pulmonary function test and arterial blood gas evaluation are of critical importance. The presence of emphysema, pleural plaque or fluid accumulation that may affect vital capacity on chest radiography is one of the most important points to be considered.

Preoperative carotid artery evaluation is extremely important especially in coronary bypass surgery. If severe carotid disease is detected, carotid and cerebral angiograms should be performed. In this case, if severe stenosis is detected, staged surgery as carotid endarterectomy followed by coronary bypass should be preferred.

Predetermination of problems that may be encountered in terms of access to the surgical field is of vital importance in minimally invasive cardiac surgery. Anatomical variations, adhesions in the pleura, presence of emphysema and mass in the lung should be evaluated preoperatively. After a detailed physical examination, computerised tomography is guiding in the evaluation of these parameters.

In minimally invasive surgery, the cannulation required for cardiopulmonary bypass is frequently performed from peripheral arteries and veins. Preoperative evaluation of the vascular structures to be selected according to the cannulation plan is of vital importance. Especially before femoral interventions, it is essential to evaluate the abdominal aorta and iliac arteries for calcification, patency and tortuosity, taking into account the length of the cannulae to be used.

Among patients with coronary artery disease, valvular heart disease and congenital heart disease, minimally invasive cardiac surgery is preferred in young patients with aesthetic concerns and in elderly patients due to the presence of comorbidities. In general, minimally invasive cardiac surgery may be preferred in isolated pathologies such as single valve or congenital lesions, pericardial and mediastinal diseases and arrhythmia surgery. In the postoperative period, conditions where chest stability is important such as severe obesity, advanced chronic obstructive pulmonary disease, severe osteoporosis, and cases where median sternotomy should be avoided such as severe chest deformity and radiotherapy are considered relative indications for minimally invasive surgery.

2.1. Contraindications for Minimally Invasive Cardiac Surgery

The most common contraindications to minimally invasive cardiac surgery include emergencies; cardiogenic shock,

aneurysm rupture, complex congenital anomalies, multiple cardiac pathologies not amenable to hybrid procedures, intramyocardially located coronary vessels, cardiac position abnormalities that make it difficult to expose the right or left atrium, vena cava occlusions, peripheral arterial diseases, aortic ectasia, severe atheromatous aortic disease with high risk of embolisation or dissection.

2.2. Advantages and Disadvantages of Minimally Invasive Cardiac Surgery

Minimally invasive cardiac interventions bring many advantages. Less bleeding, lower risk of infection, less trauma and pain, shorter intubation time and better respiratory function, better cosmetic results, shorter hospital and intensive care unit stay and recovery times, and lower hospital costs as a result of all these are widely accepted advantages. In addition to the advantages of minimally invasive cardiac surgery, some disadvantages have been reported. Possible ischaemic zone formation, risk of arrhythmia and instability, mobility of the anastomosis site and suboptimal anastomosis quality are shown as the main disadvantages.

In this section, incision types applied in minimally invasive cardiac surgery will be discussed.

3. INCISION TECHNIQUES

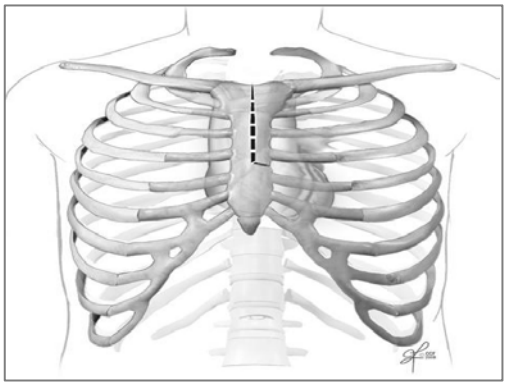
The incisions to be made in minimally invasive cardiac surgery vary according to the type of pathology.

3.1. Ministernotomy

The sternum is reached through a 5-8 cm skin incision made 3 cm below the sternal notch to the third-fourth intercostal space. From the sternal notch to the 3-4th intercostal space (depending on the location of the aortic root), a mini sternotomy

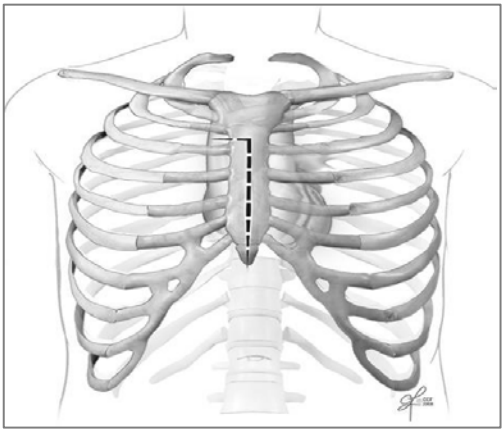
is performed in the form of an inverted T or a J-shaped mini sternotomy to the right or left with a sternal saw from the midline (Figures 1 and 2). The upper side of the sternum is opened with a small sternum retractor. This incision provides an excellent surgical approach for the aortic root and ascending aorta, pulmonary artery and right atrial appendage.

Figure 1. Upper Hemisternotomy Incision Line



Source: (Bonser, Pagano, & Haverich, 2010)

Figure 2. Lower Hemisternotomy Incision Line



Source: (Bonser et al., 2010)

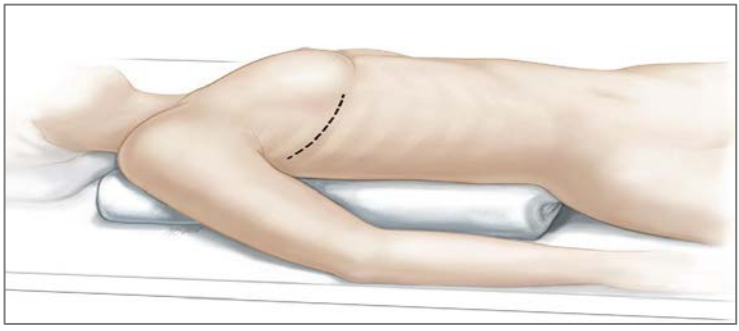
3.2. Right Anterior (Parasternal) Thoracotomy

Aortic pathologies can be operated with a right anterior mini-thoracotomy through the 2-3rd intercostal space. If this incision is preferred, deviation of the aortic arch to the right should be demonstrated by tomography before the procedure. The advantage of this method over T or J ministernotomy is the absence of a sternum incision, and the disadvantage is that the right internal thoracic artery must be ligated at the incision. The surgical appearance is similar to ministernotomy. However, cannulation techniques are also similar.

3.3. Right Anterolateral Mini-Thoracotomy

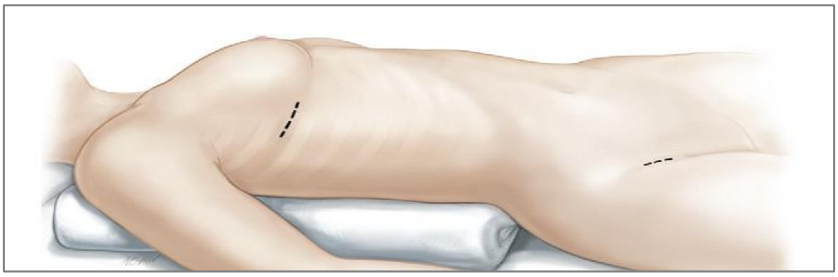
Mitral valve repair or replacement, tricuspid valve operations, atrial septal defects and intraatrial masses (myxoma) can be operated with right anterolateral thoracotomy (Falk et al., 2011; Pepper et al., 2009; Ritwick et al., 2013). This incision type is also used for atrial fibrillation surgery with or without accompanying mitral valve surgery (Gillinov & Svensson, 2007). The thorax is reached through a subareolar or submammarian 4-6 cm incision made from the anterior axillary line through the 4th intercostal space (Figure 3 and 4). Endo-aortic balloon occlusion or transthoracic aortic clamp can be used for aortic cross-clamping and antegrade cardioplegia.

Figure 4. Right Anterolateral Thoracotomy Incision Line



Source: (Carpentier, Adams, & Filsoufi, 2010).

Figure 4. Right Lateral Minithoracotomy and Femoral Cannulation Sites

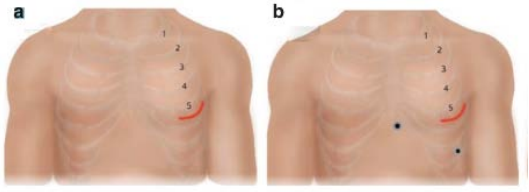


Source: (Carpentier et al., 2010).

3.4. Left Anterior Mini-Thoracotomy

Minimally invasive coronary artery bypass graft surgery via left anterior thoracotomy without sternotomy can be performed safely and effectively without cardiopulmonary bypass support or with cardiopulmonary bypass support in the working heart or with cardioplegic arrest (Figure 5). Procedures performed under cardiopulmonary bypass support allow manipulation of the heart with effective myocardial protection due to good decompression of the heart, allowing more target vessel access. In addition, in procedures performed with cardioplegia, surgery can be performed safely and effectively in an immobilised and bloodless field. Left inernal mammary artery graft preparation can be performed under direct vision, thoracoscopically and robotically.

Figure 5: Approaches For Minimally Invasive Coronary Artery Bypass Graft Surgery. (a) Left Anterior Mini-Thoracotomy. (b) Left Anterior Mini-Thoracotomy With Stabilizer Ports



Source: (Awad, Patel, Desai, & Mitrev, 2021).

4. CONCLUSION

The application of minimally invasive techniques in cardiac surgery operations can provide safe results similar to conventional methods. Although cross-clamp and cardiopulmonary bypass times are generally longer in minimally invasive surgery, these rates may decrease dramatically as surgical experience is gained. In addition, less blood and blood products are used in operations performed with minimally invasive technique. Considering the possible complications of blood and blood product use, this provides a serious advantage to the minimally invasive technique.

Postoperative pain complaints of patients with minimally invasive surgery are significantly reduced due to less tissue traction and damage, use of smaller incisions and routine use of pain catheter in patients. In this way, postoperative pulmonary care of patients can be performed more effectively and patient participation is at a high level. This parameter is also important because it is a parameter that directly affects the duration of the patient's hospital stay. Most importantly, surgical results similar to the conventional method are obtained in the minimally invasive method. The same procedure can be performed safely and successfully. There is no significant difference between both methods in terms of early postoperative mortality and morbidity. In the light of all these data, minimally invasive cardiac surgery can be performed safely and successfully by dedicated teams in centres with a high level of surgical teamwork.

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CLASSIFICATION AND SURGICAL TREATMENT METHODS OF ATRIAL SEPTAL DEFECT

Volkan Burak TABAN[1]

1. INTRODUCTION

Atrial septal defect (ASD) is a defect in any part of the atrial septum that causes abnormal shunting between the left and right atria and is defined as a connection between the two atria (Lewis & Taufic, 1953; Miyaji et al., 1997). Atrial septal defect is the most common congenital heart disease (CHD) in adults after bicuspid aortic valve and accounts for 10%-15% of CHD (Hoffman, 1990). It is observed approximately two times more frequently in women than in men. Although ASDs are frequently found in isolation, they may also be found in association with other congenital cardiac malformations.

Since the clinical symptoms and physical examination findings of ASD are not very remarkable, patients may not be recognised until adulthood. The first diagnosis is made incidentally during a routine examination in the preschool period. Although survival until adulthood seems to be the rule, almost all patients become symptomatic (palpitations, atrial fibrillation, dyspnoea, dyspnoea, paradoxical embolism) in the fourth, fifth or sixth decade in cases of unrepaired ASD related with the diameter of the defect. Spontaneous closure is rare in adult patients. When ASD is detected in early infancy, it is appropriate to wait until 2-4 years of age for closure,

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considering the possibility of spontaneous closure. In adult patients, it should be closed as soon as it is detected.

2. MORPHOLOGY AND CLASSIFICATION

In order to correctly morphologise and classify atrial septal defects, the anatomy of the atrial septum must be known; some of the defects causing shunt between the atria are outside the atrial septum. When the right atrium is opened in the surgeon position, the atrial septum extending between the inferior and superior vena cava and the septal leaflet of the tricuspid valve is exposed. However, only a small part of this area separates the two atrial cavities. The anterosuperior part of the septum is formed by the septum secundum, which separates the superior vena cava from the right pulmonary veins that drain into the left atrium. This section is called the waterstone grove on the outer surface of the heart. Inside the heart, this section corresponds to the muscular band separating the fossa ovalis from the superior vena cava. The aorta is located anteriorly under the septum and this part is called the aortic mount. Posteriorly, the oval fossa is adjacent to the inferior vena cava. The posteroinferior part is the most complex area. The oval fossa is separated from the coronary sinus and the coronary sinus from the inferior vena cava by the sinus septum. From the sinus septum extends the tendon of todora, which is formed by the junction of the thebesian and eustachian valves. The upper edge of the oval fossa extending to the tendon of todora is the true atrial septum. This area separates the right and left atria.

The area between the tendon todaro and the septal leaflet of the tricuspid valve is the atrioventricular septum. The tricuspid valve is attached to the septum lower than the mitral valve and thus the right atrium is adjacent to the left ventricle in this area. Atrial septal defects are analysed in two groups:

ostium secundum defects and atrioventricular canal defects (endocardial cusion defects).

2.1. Ostium Secundum Type Defects

It is divided into five subgroups: persistent foramen ovale, fossa ovalis defect, superior caval defect, inferior caval defect and coronary sinus defect, but as mentioned above, only the first two of these are true atrial septal defects.

2.2. Atrioventricular Canal Defects

Partial atrioventricular canal defects (ostium primum defects) and common atrioventricular canal defects are divided into two subgroups.

2.1.1. Ostium Secundum Type Atrial Septal Defect

Secundum type defects are the most common congenital heart defects. The incidence in women is twice that of men (Glenn & Baue, 1996). These defects are thought to occur as a result of excessive fenestration or resorption of the septum primum, failure of the septum secundum to develop or a combination of the 2 conditions. Central fossa ovalis defect is the most common type and 70-75% defects are in this group (Glenn & Baue, 1996).

The foramen ovale closes first functionally and then anatomically immediately after birth. If the upper one of the leaves covering the foramen ovale is too short or if the foramen ovale enlarges and remains open due to atrial dilatation, a defect called ‘persistent foramen ovale’ occurs. It has been found that the foramen ovale is open in 10-15% of normal hearts (Kaiser, Kron, & Spray, 1998).

Among sinus venosus defects, superior caval or high-level (high) venosum defects are located at the junction of the superior vena cava and the right atrium and are almost always associated with right lung upper and middle lobe venous return

anomalies. Sinus venosus defects are rarely located at the mouth of the inferior vena cava.

ASD may not always be found in the classical classification. As a matter of fact, Rakhip et al (Behramn, 2000) published a case in 1965 in which the left persistent superior vena cava opened into the left atrium with ASD and the mouth of the coronary sinus was absent. These defects, which were later named ‘coronary sinus defect’ or ‘unroofed coronary sinus’, are located in the part where the coronary sinus opens into the atrium. Usually, the wall separating the coronary sinus from the left atrium is also absent or multi-perforated and therefore causes left-right shunt. Almost all have a left persistent superior vena cava.

2.1.1.1. Patent Foramen Ovale

The patent foramen ovale is the opening between the superior extension of the septum secundum on the right atrial side and the septum primum (septum ovale) on the left atrial side. The foramen ovale is a normal site of inter-atrial communication that is present throughout fetal life. Functional closure occurs in the postnatal period. The closure of the foramen is caused by the overlap of these two septums. Due to the overlapping of the two septa and the higher pressure in the left atrium, left-to-right shunting is prevented. Extremely high atrial pressures can cause the two septums to separate. The closed foramen ovale may become a hole. Pradoxal embolisation (thrombus, air) and shunting in any direction is possible through this channel. In normal people, the foramen ovale is functionally closed shortly after birth. In 25-30% of people, anatomical closure does not occur and a potential inter-atrial canal is present.

2.1.1.2. Fossa Ovalis Defect

It is the most common type of ASD with an average rate of 70-75% (Glenn & Baue, 1996). It is localised in the middle part of the atrial septum and occurs due to failure of the septum primum. These defects may be single or multiple in the whole or only a part of the septum oval. When they are numerous, they form a fenestrated and net-like septum ovale. Sometimes the defect appears as a short septum ovale, while the defect appears as a large and incompetent patent foramen ovale.

Although the diameter of the defect is variable, it is oval in shape, 1-2 cm wide and 2-6 cm long. Septal tissue is thinned around the defect and there may be many small holes. Its edges are formed by the limbus fossa ovalis. The limbus consists of two different muscle spindles. The superior limbic band originates from the posterior right atrial wall, runs along the superior border of the fossa ovalis and attaches to the central fibrous body. The inferior limbic band originates from the side of the vena cava inferior (VCI), runs along the inferior border of the fossa ovalis and attaches to the central fibrous body.

Fossa ovalis defects are located in the region bordered by the limbus. Accordingly, tissue margins usually separate these defects from the atrial walls and atrioventricular (AV) valves. Along the posterior margin, the tissue margin may be small. These defects in different parts of the limbic septum sometimes appear large. These defects may merge with the superior and inferior vena cava orifices.

2.1.1.3. Superior Kaval (Sinus Venosus) Defect

It constitutes approximately 8% of all secundum type ASDs. These defects are located in the uppermost and posterior region of the atrial septum called the sinus venosus region. This type is closely associated with the vena cava superior (VCS) inflow. One or more pulmonary veins, usually from the right

lung, drain abnormally into the VCS. Sometimes this defect is even present in the VCS, so that part of the systemic venous blood enters the left atrium. This may rarely cause cyanosis.

The inferior limbic part of the defect is associated with the lumen of the superior vena cava. The orifice of the VCS is displaced to the left and overlaps the right and left atrium. This defect is frequently associated with the opening of the right upper and middle lobe pulmonary veins into the VCS or right atrium. When superior caval type ASD is identified by echocardiography, associated venous return anomalies must be investigated.

The clinical picture, haemodynamic disturbances, electrocardiography and telecardiography are similar to those seen in other secundum ASDs. The diagnosis is usually made by echocardiography. Transesophageal echocardiography (TEE) may be used if necessary. If cardiac catheterisation is to be performed to better define venous drainage, the catheter is sent from the caval vein directly into a right pulmonary vein. Surgical correction is usually performed by converting the entrance of the abnormal pulmonary veins to the left atrium and placing a patch to close the defect. Surgical results are generally favourable (Moss, 2008).

2.1.1.4. Inferior Kaval Defect

This defect, which constitutes 20% of ASD types in the clinic, is thought to be responsible for the lack of development of the coronary sinus roof. It is a defect of the anterior inferior part of the fossa ovalis. It is characterised by partial or complete absence of the interatriatal septum between the left atrium and the coronary sinus. Persistent left superior vena cava is present in most cases. The lower lobe vein of the right lung may be abnormally connected to the inferior vena cava or right atrium (Scimitar syndrome). This type of pulmonary venous return

anomaly is observed more frequently than the superior caval type (Çağlı, Ege, & Paç, 2004; Vick & Titus, 1990).

2.1.1.5. Coronary Sinus Defect

These defects are rare and are located in the part of the coronary sinus opening into the atrium. Developmental deficiency of the coronary sinus roof is considered responsible. It is usually hypoplastic and localised in an area bounded by the inferior limbic septum, the atrioventricular portion of the membranous septum and the VCI orifice. Usually the wall separating the coronary sinus from the left atrium is absent or multi-perforated. Therefore, left persistent superior vena cava is present in almost all of these defects causing left right shunt. Raghip et al. reported a similar case in 1965 in which the left persistent superior vena cava opened into the left atrium with ASD and the coronary sinus mouth was absent (RAGHIB et al., 1965).

2.1.2. Atrioventricular Canal Defects

Atrioventricular canal defects (endocardial cushion defects) are analysed in two sections as common AV canal defects and partial AV canal defects (ostium primum defects). The terms common and partial AV canal defects were first used by Rogers and Edwards (Rogers & Edwards, 1948).

2.1.2.1. Common AV Canal Defect

It is the most severe form of atrioventricular canal defect. There is a deficiency in the lower part of the atrial septum and the upper muscular part of the ventricular septum and a common AV valve overlapping the ventricular. It is in the form of inability of the primitive canal to separate into two separate AV openings. There is a common valve in the orophysis between the atrium and ventricles. The anterior valve of the common AV valve originates from the ventral AV endocardial cushion and

forms the anterior parts of the mitral anterior and septal tricuspid valves. There is a significant gap between the ventricular septum below and the anterior and posterior valves above. In a significant proportion of such cases, there is a common connection between the ventricles.

In a study by Jeffrey P. Jacops et al. a 5-level classification was made for atrioventricular septal defects (EC, 1923). At the first level, the disease is named. In the second level, the type of the defect is analysed. In the third level, it is analysed whether the ventricles develop equally. In the fourth level, the anterior common leaflet of Rastelli is classified according to its differentiation. Rastelli classified complete defects as A, B, C at the fifth level. In Rastelli Type A, the anterior common leaflet is differentiated into two as right and left. The left anterior leaflet is attached to the left ventricle and the right anterior leaflet is attached to the right ventricle. Rastelli type B is less common. The right-sided abnormal papillary muscle extends to the left side and adheres to the common left anterior leaflet. In Rastelli Type C, the common anterior leaflet, which does not have any chordal leaflet, fluctuates freely on the ventricular septum (Khonsari &Sintek, 2008). The majority of patients develop Eisenmenger syndrome after the age of 1 year. Therefore, patients should be operated before the age of 1 year. It is frequently seen in children with Down syndrome. In the common AV canal, the defect is in the lower part of the interatrial septum as in ostium primum type ASD and the defect extends to the upper part of the ventricular septum. There is also a cleft in the mitral and tricuspid valves.

2.1.2.2. Ostium Primum Type ASD (Partial AV Canal)

In ostium primum ASD, there is a septal commissure between the superior and inferior valves of the left AV valve

and a cleft in the atreior mitral valve. The defect is inferior to the interatrial septum. The mitral and tricuspid valves form the base of the defect. An ASD with an ostium primum in the lower part of the atrial septum is characterised by a defect in the mitral valve alone or with a tricuspid valve cleft, or by a lack of ventricular septum. The tricuspid valve has no cleft or shows a minor central deficiency. The upper edge of the incomplete ventricular septum and the ventricular faces of the anterior mitral valve elements merge, preventing the connection between the ventricles. If there is no atrial septal tissue, a common atrium or a single atrium is recognised.

There is mitral regurgitation due to a cleft in the anterior leaflet of the mitral valve. The left ventricle is under load due to volume overload. Pulmonary hypertension may develop in the early period.

3. CLINICAL

The diagnosis of ASD can be easily missed. When the diagnosis is made, half of the patients are asymptomatic and the first diagnosis is made incidentally during a routine examination performed in the preschool period. In 60% of patients, symptoms start to develop in the 3rd decade and become more prominent after the 4th decade(Glenn & Baue, 1996). Patients with a pulmonary-systemic flow ratio (Qp/Qs) between 1.5-3 and normal pulmonary artery pressure are asymptomatic. Patients with a flow ratio above 3 have rapid fatigue, dyspnoea and heart failure may develop. These patients have frequent upper respiratory tract infections. Cyanosis in ASD may be observed only in patients who develop pulmonary hypertension (Mahoney, 1993). Cyanosis is more prominent in inferior caval defects associated with total abnormal pulmonary venous return, single atrium, and severe pulmonary stenosis. Haemoptysis may

occur in cases of increased pulmonary vascular resistance and pulmonary artery thrombosis.

Anomalies such as growth retardation, pectus excavatum, arachnodactyly, kyphoscoliosis and high palate may be observed in patients with ASD. The type of ASD associated with skeletal disorders especially in the hands and upper extremities is named 'Holt-Oram Syndrome' (Holt & Oram, 1960). Paradox embolism may occur when the right atrium pressure exceeds the left atrium pressure for any reason.

Physical examination findings of ASD depend on the degree of pulmonary blood flow and pulmonary vascular resistance. A systolic beat may be palpable in the lower left part of the sternum due to enlargement of the right ventricle. Trill is very rare in patients without pulmonary hypertension. On listening, the first heart sound is usually intensified and the second heart sound shows constant coupling due to delayed right ventricular emptying. In the absence of pulmonary hypertension, the second heart sound is slightly intensified. A moderate pulmonary systolic ejection murmur is almost always present due to increased blood flow through the pulmonary valve. If it is very strong, a concomitant pulmonary stenosis should be suspected. A middiastolic murmur is heard at the lower left edge of the sternum due to increased blood flow through the tricuspid valve. Sometimes this murmur may spread to the apex and may be confused with mitral stenosis murmur.

4. TREATMENT

There is no specific and definite medical treatment for atrial septal defects. The main treatment of atrial septal defect is transcatheter or surgical closure of the defect.

4.1. Indications for Closure of Atrial Septal Defect

Large right ventricular volume overload defects usually cause symptoms in the third decade of life. Closure of these large ASDs is generally indicated to prevent complications such as atrial arrhythmias, haemodynamically severe tricuspid regurgitation, left-right shunt and embolism during pregnancy, marked congestive heart failure or pulmonary vascular disease which may develop in 5-10% of affected individuals (Kirklin, 1993).

Ostium secundum type ASDs should be closed if the pulmonary blood flow is 1.5 times higher than the systemic blood flow. If the shunt ratio is below 1.5, the defect may not be closed because the life expectancy is the same as in normal individuals. Right ventricular hyperthyrophy, the size of the defect on echocardiography and the size of the heart on telecardiogram are taken into consideration when deciding on the timing. However, when the diagnosis is made after the age of 5-6 years, there is no need to wait for closure unless the defect is small (Kirklin, 1993).

If the pulmonary vascular resistance is between 8-12 (dyne*san)/cm and decreases when a vasodilator drug is given or with 100% oxygen, the defect should be closed because it has been shown that functional capacity is better after ASD closure compared to those who are medically monitored (Dore, Glancy, Stone, Menashe, & Somerville, 1997).

4.2. Contraindications to Closure of Atrial Septal Defect

The most important contraindication is the development of pulmonary vascular disease characterised by increased pulmonary vascular resistance. Patients are considered inoperable if pulmonary vascular resistance is above 12 wood units or pulmonary vascular resistance is between one-half and

two-thirds of systemic resistance. It is thought that mortality may be high in these cases. It is accepted that pulmonary vascular disease will continue to progress even if the defect is closed surgically. Therefore, surgery is contraindicated in patients who are cyanotic and have a very high pulmonary vascular resistance and a shunt ratio of 0.6-1.2.

There is a special situation for patients diagnosed with ASD during pregnancy. It is known that blood volume increases by 50% during pregnancy. This increase in blood volume increases the amount of shunt in pregnant women. Therefore, heart failure can be seen in the 3rd trimester of pregnancy. For these reasons, it is necessary to avoid a surgical treatment approach in a woman with ASD in the 3rd trimester. Because the risks to life of both the mother and the foetus will be quite high as a result of the surgical procedure to be performed. As the treatment method that can be applied in these patients, it should be ensured to overcome this period with medical treatment and rest in the first application. After this period, the operation should be planned when stable conditions are obtained (Ponnuthurai et al., 2009).

4.3. Asd Closure with Transcatheter

In 1976, King and Miles reported percutaneous closure of ASD defects (King, Thompson, Steiner, & Mills, 1976). Transcatheter closure may be applied or surgery is recommended when it is not suitable. Sinus venosus, coronary sinus and primum defects are not suitable for closure by device (Warnes et al., 2008).

As an alternative to surgical treatment, defects located in the fossa ovalis have been closed by interventional method in recent years. The amplatzer septal occluder and transcatheter closure method have come to the forefront with its ease of application and high success rate. The transcatheter closure

procedure is limited to defects with a diameter of 5-15 mm and FDA approves the closure of defects smaller than 40 mm. There is a 10% failure rate during the application of this procedure. These include device migration, embolisation requiring operation and residual shunt (Hill et al., 2000).

While successful results were reported in more than 90% of the cases, researchers have attempted new devices due to breakage of the arms of the device. Today, there are many devices in use and studies on the effective use of these devices are ongoing (Formigari et al., 1998).

4.4. Surgical Treatment

Nowadays, ASD closure is easily and safely performed with cardiopulmonary bypass (CPP). In this way, the ASD can be closed with no residual defect and additional anomalies such as partial anomalous pulmonary return can be repaired. The most commonly used method for this procedure is surgery through the median sternotomy incision.

In recent years, minimally invasive procedures performed through right anterolateral thoracotomy, transxiphoid or subxiphoid incision have become more popular in the closure of ASD. The aim of these procedures is to shorten the hospitalisation period, to obtain better aesthetic results, to apply small incisions in the patient and to reduce the cost of the surgical intervention.

Small defects can be closed primary using the continuous suture method. However, large defects can be closed using an autogenous patch such as pericardium or an artificial patch such as dacron and Teflon. However, if the patient to be operated on has mitral and tricuspid regurgitation, the jet flow hitting the patch may cause severe haemolysis. Therefore, pericardium is preferred in patch closure (Peter, 1999).

After standard median sternotomy, aortabicaval cannulation is performed. The cavas are rotated with tapes. Superior caval cannulation is performed from the right atrial appendage and inferior caval cannulation is performed by placing a purse string suture below the caval junction. If there is a high-level ASD, it is necessary to visualise the pulmonary vein and the superior vena cava cannula is placed higher than this point. After cannulation, the pump is entered. The patient is usually cooled to 30-34ºC. The degree of hypothermia can be further decreased in complicated cases with the possibility of prolongation. Today, the operative approach is usually performed together with aortic cross clamp and cardioplegic infusion.

4.4.1. Right Atriotomy

It is carefully performed obliquely through the anterior crista terminalis, preserving the sinoatrial node and major interatrial pathways. With a good exploration, the diameter and localisation of the ASD, the orifices of the four pulmonary veins, the arioventricular valves, the coronary sinus, the orifices of the superior and inferior vena cava, the eustachian valve and all anomalies that may be associated with ASD are evaluated. Closure of the defect starts from the edge close to the VCI. Since the most residual defect is seen in this part, special attention should be paid to avoid an opening during suturing.

4.4.2. Repair of Fossa Ovalis Type Defects

Approximately three quarters of these defects are closed by passing shallow continuous sutures through the atrial tissue. The main criteria for closure are the shape and size of the defect, and whether there is an increase in tension or folding at the corners of the defect during closure, and the decision to use a primary or patch graft is made. For primary closure, there should be no tension in the edge tissue or the surrounding septal

tissues should hold the sutures strongly. If these conditions are not met, patch closure is more appropriate. As a result, arrhythmias that may be caused by tension in the postoperative period and the possibility of residual shunt formation are eliminated.

Autologous pericardial tissue is the most commonly used material for patch. Because the possibility of haemolysis caused by impact to the graft in the use of pericardial graft is much less compared to other synthetic grafts. Other advantages of pericardium are that it is easy to obtain, autologous and does not bring additional cost. When the defective part is repaired, the outer surface of the pericardial tissue should come to the right atrium and the inner surface to the left atrium.

4.4.3. Repair of Supererior Tibial Defects

The patch is usually used so that the associated pulmonary venous return anomalies are directed to the left atrium. The atrial incision is extended towards the VCS for easy patch placement. Care should be taken to avoid injury to the sinoatrial node during this incision. Transatrial and transcaval approaches sometimes facilitate the procedure. A small branch of the pulmonary vein may join the VCS from above, which is rarely seen and usually does not require intervention. Intervention of this vein, which joins the VCS from above, is generally not considered appropriate due to caval occlusion and narrowing that may occur as a result of intervention. Left-right shunts here usually do not cause haemodynamic problems.

4.4.4. Repair of Inferior Caval Defects

Care should be taken not to cause compression of the inferior orifice of the vena cava. The inferior edge of the defect and the ostachian valve should be well evaluated and should not be confused with each other. In inferior caval type defects closed with patch graft, the suture line is carefully placed on the

inferior part without falling behind the defect wall. The lumen of the VCI should be sacrificed to avoid the possibility of tunnelling between the left atrium and the VCI.

4.4.5. Repair of Coronary Sinus Type Defects

In the presence of left superior vena cava, triple venous cannulation should be performed after routine procedures. However, double venous cannulation and short-term left VCS occlusion may be attempted in case of left-right VCS connection. Moderate hypothermia is performed. Depending on the condition and location of the defect, the defect is closed with a pericardial patch with drainage to the left atrium. In mild window-shaped defects, patch closure is performed, taking care not to damage the atrioventricular node and not to narrow the mouth of the coronary sinus. This risk is seen in the anteroseptal rim of the patch.

If the roof of the coronary sinus is not formed with the left VCS (unroofed coronary sinus), a complex repair should be performed. The left superior vena cava opens into the left atrium above the opening of the left superior pulmonary vein. In most cases, there is no connection between the right VCS and the left VCS. In the repair procedure, the native atrial tissue is cut, paying attention to the atrioventricular node in the Koch triangle. The well-measured pericardial patch is repaired with a continuous suture so that the pulmonary venous returns are below and to the left of the patch and coincide with the mitral valve orifice. In addition, both VKS orifices are directed towards the right atrium and tricuspid valve with BMI. In the Tunnal method, drainage of the left VCS from the left to the right atrium is provided as an alternative. However, this method is not recommended in very large babies because of the risk of occlusion.

If there is a connecting vein between the left VCS and the right VCS, this vein is ligated close to the heart and the connection is eliminated and the coronary sinus is repaired with a patch. However, ligation of this vein is not recommended in the absence or insufficiency of the connecting vein.

In some patients, abnormal drainage of one or more pulmonary veins to the right atrium may be observed. In such a case with pulmonary venous return anomaly accompanying ASD, the defect is sutured with a patch so that the mouth of these veins remains in the left atrium.

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