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The promising role of different imaging diagnostic modalities for percutaneous transcatheter device closure of secundum atrial septal defect in pediatrics in Sohag university hospital

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Abstract

Purpose of the review

This study was conducted for diagnosis of secundum atrial septal defect (ASD) in Pediatrics department at Sohag University Hospital to review current different imaging diagnostic modalities for percutaneous device closure of secondum ASD.

Background

Two-dimensional trans-esophageal echocardiography (2DTEE) was applied to patients before selection and during device deployment and three dimensional TEE (3DTEE) can provide unique anatomy that aid in improving device closure of secondum ASD in pediatrics patient, 3DTEE provides unique en face views of ASDs. (1)

Conclusion

Transcatheter closures of secondum ASD are established cardiovascular interventions that are now being performed more than surgical closure in vast majority of the pediatric patients; multimodality imaging is required for proper patient screening, procedure indication and to deliver these transcatheter therapeutics safely and effectively. These include TTE, 2DTEE and 3DTEE; highly significant correlations exist between 3D derived ASD maximum diameter ad maximum diameters using 2DTEE.

Key words: atrial septal defect, 2DTEE, 3DTEE, ASD II device.

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Introduction

Secundum atrial septal defect (ASD II) is a congenital heart defect in which blood flows between the atria (upper chambers) of the heart,[(2)] it is one of the most common congenital heart disease with an incidence of 6 to 10 per 10,000 live births,[(9)] oxygen-rich blood can flow directly from the left side of the heart to mix with the oxygen-poor blood in the right side of the heart; or the opposite [(3)]

Morbidity and Mortality

In developed countries, mortality rate of Atrial Septal Defect is low (< 1%).[(4)] Patients with ASDII may have an embolic stroke or congestive heart failure (CHF).[(5)]

Clinical picture

A- symptoms:

Isolated secundum ASDs, and small AS-DII, do not cause symptoms in infancy and childhood, however, some newborns have mild cyanosis due to right-to-left shunting across the ASD II. Infants with large ASDs may present with symptoms of heart failure, recurrent respiratory infections, or failure to thrive.[(6)], moderate to large ASDII, left-to-right shunting presented by heart failure, hepatomegaly, and elevated jugular venous pressure, other symptoms includes atrial arrhythmias, exercise intolerance, dyspnea and fatigue.[(7)] Symptoms also include decreased exercise tolerance, easy fatigability, palpitations, and syncope. [(7, 8)]

B-Signs

The physical findings in patient with an ASD II include a systolic ejection murmur may be heard that is attributed to the pulmonic valve,[(9)] In unaffected individuals, respiratory variations occur in the splitting of the second heart sound (S2).[(10)] In individuals with an ASD II, a fixed splitting of S2 occurs because the extra blood return during inspiration gets equalized between the left and right atria due to the communication that exists between the atria [(7)]

Etiology

Genetic factors

Provides further support for a genetic etiology a hypothesis of multifactorial etiology has been proposed, in this type of inheritance, the genetic predisposition of the individual interacts with other genes and/or environmental factors to cause heart disease. Findings related to NXK2.5 validate the concept of pediatric heart disease specially ASD II.[(10)]

Environmental factors:

Atrial septal defect is a structural problem that occurs during heart development while a baby is still in the womb. Genetics, certain medical conditions, use of certain medications, and environmental or lifestyle factors, such as smoking or alcohol misuse, rubella and CMV infection may play a role.

Diagnosis

CHEST X-RAY

Common Findings

1)Prominent pulmonary artery, increased pulmonary vascular markings.
2)Cardiomegaly due to right atrial and ventricular enlargement.
3)Normal appearance of heart vasculature.[(11)]

Imaging modalities for ASD II evaluation and diagnosis

Echocardiography

I-Transthoracic 2D echocardiography (TTE 2D)

Transthoracic echocardiography (TTE) has led to dramatic improvements in cardiovascular medicine, and is now the most widely used diagnostic cardiac test after electrocardiography (ECG), standard echocardiographic examination allows the physician to obtain crucial information on cardiac structures, function, and hemodynamics in a remarkably quick and, most of all, totally non-invasive way.[(12)]

Advantages

1-The most widely used ultrasound modality to evaluate the IAS is TTE, which remains the preferred initial diagnostic modality for the detection and diagnosis of ASDII.[(13 and 14)]

2-TTE is especially useful in small children in whom the ultrasound image quality will typically permit a full diagnostic study. It can also be used for patient selection and real-time transcatheter ASDII closure.[(15, 16 and 17)]

3-As with TTE it is important in assessment of right heart and pulmonary arterial dilation.[(18)] However, TEE is required to further characterize the atrial septal abnormalities, because the TTE image quality will not always permit a comprehensive evaluation of the IAS. [(19)]

4-Two-dimensional transthoracic echocardiography (2D TTE) is utilized also to assess patients with CHDs; it is noninvasive and readily available and needs less cooperation from the patient, while it does not rely on harmful radiation.[(20)]

Limitations of 2D TTE

2D-TTE is safe and efficient to guide percutaneous ASD II closure; it allows a shortened and simplified procedure performed in spontaneously breathing children. Our results strongly support the fact that 2D-TTE can be considered as an efficient alternative to 2D-TEE for assessment and guidance of pediatric ASD II closure, so there is few limitations for 2D TTE.[(21)] it has limited ability to interrogate the lower rim of atrial septal tissue above the IVC after device placement because the device shadowing interferes with imaging in virtually all planes.[(17)]

Technique of TTE 2D in ASD II

ASD II rims and size were assessed preoperative by TTE in all patients.

Right ventricular size and function were assessed according to American Society of Echocardiography guidelines.[(22)]

Right ventricular systolic pressure was estimated using the Bernoulli equation in patients with tricuspid regurgitation; the ASD II diameter was measured in apical and sub-costal four-chamber views.[(23)]

And the largest ASD II diameter on any view was recorded as ASD II size measured, LA length was estimated as 0.597+0.404·log(Body Surface Area).[(24)] Very large ASD II was defined as an echocardiographic diameter ≥15 mm/m2 in children,[(25)] We labeled ASDII rims as universally accepted, as aortic , atrioventricular valve, inferior venacaval, posterior, superior venacaval, and superior rims [(26)] ,rims less than 5 mm in length were considered deficient[(27)] **,**TTE was used also after device deployment and before its release, TTE was used to evaluate the position of each disk and potential relation of the device on adjacent cardiac structures, the relation of the device to the atrioventricular valves and the aorta was assessed using the parasternal short-axis, the apical 4-chambers and the subcostal views.[(28)]

Transosophageal 2D echocardiogramphy (TEE 2D)

For assessment of ASD II morphology, including maximum defect dimensions and surrounding tissue rim, 2D TTE is somewhat limited ,so2D (TEE) which assess the size, location, and tissue rim surrounding ASDs to determine suitability for trans catheter repair, TEE is considered a semi-invasive procedure so is undertaken only after initial evaluation with TTE. [(25)]Trans esophageal echocardiography provides highly detailed imaging of the IAS, surrounding structures, catheters, and closure device during trans catheter closure, it requires either conscious sedation, with the attendant aspiration risk in a supine patient, or general anesthesia, with an endotracheal tube placed to minimize aspiration risk. [(29)]

Advantages

1-TEE can identify the margins or rims of the ASD II and assess the surrounding structures (e.g., aorta, cavae, pulmonary veins, AV valves, and coronary sinus.)

2-TEE 2D has enhanced the evaluation of ASD II by clearly defining the IAS anatomy and enables all views of the defect and its surrounding structures, two-dimensional trans esophageal echocardiography (2D TEE) is the gold standard for all trans catheter occlusion techniques and a reliable imaging procedure ASD II measurements.

3-Not only can 2D TEE provide useful data regarding the position, size, and number of defects but also it can evaluate the surrounding structures, It is also effective in guiding device deployment in proper opening and positionning.[30]

Technique of TEE 2D

As with TTE, multiple and sequential TEE 2D views should be used to completely and systematically evaluate the IAS, the size, shape, and location of any atrial communication present, and the relationship of the defect to its surrounding structures, Two dimensional images should be optimized and color Doppler mapping subsequently applied, the color Doppler scale can be reduced slightly to approximately 35–40 cm/sec to capture low-velocity flow across a small fenestration, or smaller ASD II, Pulsed and continuous wave Doppler should then be used to measure the velocity, direction, and timing of flow ,A deficient rim is defined as less than 5 mm in multiple sequential views, and this should be evaluated in at least three sequential related multiplane views, when using TEE, five base views are used to assess the IAS and surrounding structures, these key views include the upper esophageal short-axis view, midesophageal aortic valve (AoV) short-axis view, midesophageal four-chamber view, midesophageal bicaval view, and midesophageal long-axis view.[31]

Trans-catheter device closure of secondum ASD has well-established efficacy and safety, for most pediatric patients with suitable anatomy; it is the preferred method for treating ASD II.

It has favorable rates of technical success and less risk of adverse events when compared to operative closure of ASD.[3,8]

It has demonstrated equal efficacy at closure with excellent safety in comparisons to surgical closure.[3,6,8] It is noninvasive technology and it is less discomfort, superior cosmesis, and shorter hospital length of stay.[10] but its risk includes device embolization, thro-mbus formation, bleeding, and erosion.

Anatomical types of ASD

The ostium secundum defect is the most common ASD, accounting for 70% of all ASDs. It is due to an abnormal development of the septum that separates the left and right atrial chambers[34] , There are other types of ASD, Only the central defect of the septum secundum type is amenable to percutaneous closure.[34,37]

Pathological effect of ASD

ASD results in volume overload of the pulmonary circulation and right ventricle through left to right shunting between the atria, The diagnosis is confirmed by echocardiography with color flow Doppler.[9,10] In advanced disease, severe increases in right-sided pressures may cause shunt reversal, which portends a poor prognosis.[32,37]

Indications for transcatheter closure of atrial septal defects

ASDs are considered for closure in symptomatic patients where a left to right shunt is present with evidence of right heart pressure overload (right atrial or ventricular enlargement), and pulmonary to systemic blood flow ratio (Qp:Qs) is greater than 1.5:1. In addition to right heart overload and Qp:Qs > 1.5:1, asymptomatic patients, those whose pulmonary artery pressure is less than 50 percent systemic arterial pressure, and pulmonary vascular resistance is greater than one third the peripheral vascular resistance, without exercise induced cyanosis, are recommended for ASD II closure. [33]

Diagnosis

Diagnosis is usually made by transthoracic echocardiogram (TTE) and transesophageal echocardiography (TEE).[37,34]- The TEE assesses the following: shunt presence, direction, shunt ratio, defect size, position, presence of pulmonary hypertension, and right ventricular dysfunction.[34,37] The defect complexity is determined by the ASD rim size, defect diameter, shunt ratio, shunt direction, interatrial septal aneurysm excursion, floppy adjacent tissue and proximity to aorta.[37] Rim deficiency is an important indicator of potential complications especially with values less than 5 mm in anterior, inferior or superior aspects of the ASD.[34,36,37]

Deployment procedure

The patient is required to have antibiotics before procedure and heparin under general anesthesia, venous access from the right femoral vein is obtained. Using a 6F sheath, stiff wire crosses the defect and is placed in the superior pulmonary vein. The size of the sheath is determined by the size of the device. The common procedural risks include air embolization and technical difficulties.[37]

Successful closure

Complete closure with residual shunt >1–2 mm and stable device position, The Boutin classification for residual shunt is as follows: mild <1–2 mm; moderate 2–4 mm and large ≥4 mm[13] Mild–moderate shunts may improve or disappear with endothelialization of the device.

Three-dimensional transesophageal echocardiogram

After completing 2DTEE, patients more than 25 kg 3D TEE data were obtained using the vivid E9 GE machine TEE 6VT probe, We used the 3D zoom prepare modality for image acquisition. In 3D TEE, the bicaval view was acquired at the mid-esophageal level with the transducer starting at the 90 to 120 degrees. The depth of pyramidal data sets was adjusted to include only the left and right sides of the atrial septum in this view to allow the entire septum to be acquired in a 3D format without incorporating the surrounding structures. With a 90 degree up–down angulation of the pyramidal data set, the entire left-sided aspect of the septum could be shown in an “en face perspective”, Once the left side of the atrial septum has been acquired, a rightward tilting of the volume will show the right side of the atrial septum and the fossa ovalis as a depression on the septum. In some cases, fine cropping was necessary to remove the surrounding atrial structures obscuring the septum.

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