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Improvement Functional Capacity In Adult After Percutaneous ASD Closure

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Abstract:- This case report describes a 24-year-old woman with a secundum atrial septal defect (ASD) who underwent successful percutaneous ASD closure with significant improvement in symptoms and functional capacity. The patient presented with easy fatigue and shortness of breath on exertion for 10 years. Echocardiography revealed a large secundum ASD with moderate to severe tricuspid regurgitation, mild mitral regurgitation, mild pulmonary regurgitation, and dilatation of the right atrium and ventricle. Right heart catheterization confirmed a large left-to-right shunt and pulmonary hypertension. The patient underwent ASD closure with a Figulla Flex II device, resulting in immediate improvement of hemodynamics. Follow-up at 3 and 6 months demonstrated decreased right ventricular size, improved left ventricular function, and increased exercise capacity. This case highlights the benefits of ASD closure in improving symptoms and cardiac function, even in patients with longstanding right ventricular dilation.

Keywords:- *ASD Closure, 6 MWT, Increased of Functional Capacity, Percutaneous Closure, Echocardiography After Closure.*

I. INTRODUCTION

Atrial septal defect (ASD) of the secundum type is a frequently observed congenital heart defect, typically appearing as a standalone abnormality, in approximately 3 out of every 10,000 live newborns (Meissner et al., 1999). Infants may exhibit inadequate growth, frequent infections in the lower respiratory tract, and heart failure, while older children may experience weariness and difficulty breathing. A significant number of children with a mild left-to-right shunt do not show any symptoms, and the disease is identified during a regular assessment of a heart murmur. Elective surgical repair is the preferred treatment for an atrial septal defect (ASD) with a significant pulmonary to systemic flow ratio (Qp:Qs ratio of 1.5:1) in the juvenile population, regardless of the presence of symptoms. The decision to pursue this treatment is justified by the following observations: (1) While patients with uncorrected secundum ASD can live to an advanced age, their overall life expectancy is reduced; (2) The mortality and morbidity rates for surgical closure are currently at 1% and even lower for percutaneous closure; and (3) Studies have demonstrated that survival rates after surgical closure are comparable to those of a control population of the same age. These patients frequently come to the attention of medical professionals due to an irregular electrocardiogram (ECG), chest x-ray, or the identification of a cardiac murmur, occasionally during pregnancy. Typically, they refuse to acknowledge any symptoms despite a substantial flow of blood from the left side to the right side of the heart. The objective was to assess if elective percutaneous ASD closure in asymptomatic or mildly symptomatic adults resulted in any immediate positive effects. This was done by examining exercise capacity and right ventricular dilatation nine months following the procedure (Khan et al., 2010).

Percutaneous atrial septal defect (ASD) closure in adult patients has been associated with significant improvements in functional capacity. Studies have consistently shown that adult patients, particularly those over 40 years old, experience enhanced functional class, exercise capacity, and right ventricular function following percutaneous ASD closure (Khan et al., 2020; Ostovan et al., 2016; Komar et al., 2014; Prochownik et al., 2018; Herrmann et al., 2005). This improvement in functional capacity is irrespective of age, with reverse right heart remodeling and improved exercise capacity observed in both younger and older adult populations (Enache et al., 2021; Jung et al., 2013). Additionally, percutaneous closure of ASDs has been linked to benefits such as improved cardiac remodeling, normalization of atrial and ventricular volumes, and decreased right atrial area and pulmonary artery pressure (Santoro et al., 2006; Teo et al., 2008; Shafei et al., 2022). Furthermore, studies have highlighted the hemodynamic and functional enhancements in right ventricular function post ASD closure, whether through surgical or percutaneous means (Kamphuis et al., 2019; Rao & Harris, 2017; Salehian et al., 2005). The closure of ASDs with left-to-right shunts has shown demonstrable benefits in terms of improved right ventricular function and overall functional capacity (Luermans et al., 2009; Alstrup et al., 2021; Baykan et al., 2015). Notably, closure of ASDs in elderly patients has been found to result in significant clinical and hemodynamic improvements, justifying the procedure even in older age groups (Alexandre et al., 2023; Jung, 2007; Egred et al., 2007; Bissessor, 2015; Komar et al., 2014). In conclusion, percutaneous ASD closure in adults leads to a wide array of positive outcomes, including improved functional capacity, reverse heart remodeling, enhanced exercise tolerance, and better cardiac function. These findings underscore the effectiveness and benefits of percutaneous ASD closure in improving the overall health and well-being of adult patients with ASDs.

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II. LITERATURE REVIEW

Improving functional capacity in adults after percutaneous atrial septal defect (ASD) closure has been a topic of interest in recent literature. Studies have shown that percutaneous closure of ASDs can lead to significant improvements in cardiac function and exercise capacity. For instance, demonstrated that global left ventricular function improves after percutaneous ASD closure (Teo et al., 2008). Additionally, highlighted that transcatheter closure of ASDs was associated with improvements in both left ventricular (LV) and right ventricular (RV) function (Schoen, 2005). This improvement in exercise capacity has been observed to occur gradually over time, with studies indicating that significant enhancements in physical capacity can be evident as early as 24 months post percutaneous ASD closure (Prochownik et al., 2018). Furthermore, studies have shown that percutaneous ASD closure can lead to reverse right heart remodeling, improved functional class, and exercise capacity, regardless of the patient's age (Enache et al., 2021). This improvement is not limited to the right heart, as device ASD closure has been shown to reduce left atrial volume and improve both right and left ventricular function, enhancing functional capacity even in asymptomatic adults (Foo et al., 2018). Moreover, studies have indicated that closure of ASDs can result in hemodynamic and functional improvements in both the right ventricle (RV) and left ventricle (LV) (Bastian et al., 2017). In conclusion, the current body of literature supports the notion that percutaneous ASD closure in adults can lead to significant improvements in cardiac function, exercise capacity, and overall quality of life. These improvements are observed not only in the right heart but also extend to the left heart chambers. The studies reviewed provide valuable insights into the long-term benefits of percutaneous ASD closure and highlight the importance of considering this intervention for adults with ASDs to enhance their functional capacity and overall well-being.

III. CASE PRESENTATION

A 24-year-old lady was admitted to the hospital with a chief complaint of chronic fatigue that has been present for the past decade. She also experiences shortness of breath, particularly following strenuous physical exercise. The patient has no history of palpitation, chest discomfort, cyanosis, recurrent cough, or cold. The patient is the second offspring among a total of three siblings. Birth history: The patient was delivered at home with the assistance of a nurse using conventional methods. The acronyms BBL and PBL are unknown. The mother's medical history during pregnancy does not include any reported problems. There is no familial history of congenital heart disease. The patient was diagnosed with congenital heart disease 6 years ago and is currently prescribed sildenafil 50mg. The clinical examination showed no signs of cyanosis, anemia, or jaundice. The hemodynamic parameters were within the normal range, with a blood pressure of 90/70 mmHg and a pulse rate of 70 bpm. During the examination, a grade 3/6 systolic murmur was identified at the upper left sternal boundary using auscultation. The laboratory tests yielded results that fell within the usual range. The chest x-ray reveals cardiomegaly with a shown left to right shunt, but the pulmonary region appears to be within normal limits.

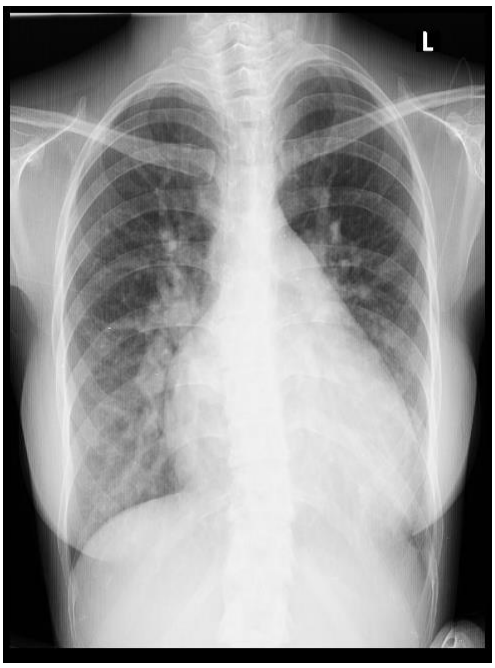

Fig 1 Thoraks X-Ray;Cardiomegaly

An echocardiography demonstrated atrial septal defect secundum bidirectional shunt, moderate to severe tricuspid regurgitation with high probability of PH, mild mitral regurgitation, mild pulmonal regurgitation, with dilatation of RA and RV.

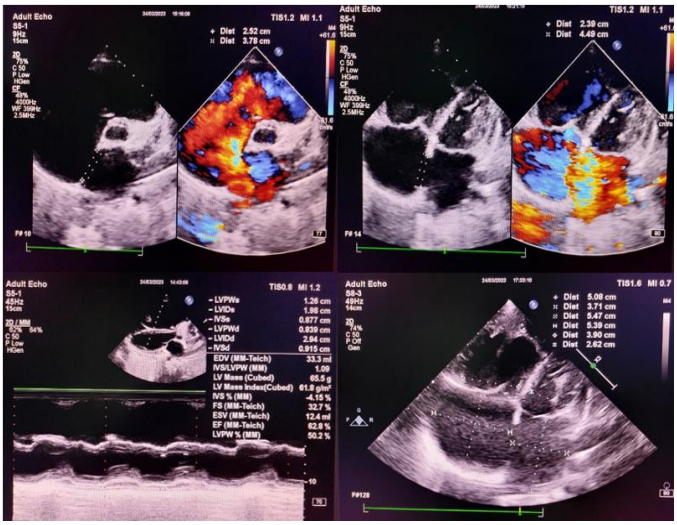
Fig 2 Echocardiography; ASD Secundum

Transesophageal echocardiography showed ASD secundum Left to Right shunt, Moderate to severe tricuspid regurgitation, mild mitral regurgitation, mild pulmonary regurgitation. Right heart catheterization was result ASD secundum Left to Right shunt with high flow, low resistance and pulmonary hypertension. The patient then underwent ASD device closure with maximum diameter 28 mm, RIM was adequate. ASD was closed using the Figulla Flex II ASD occlude device number 34 mm with TEE guiding and fluoroscopy with good results.

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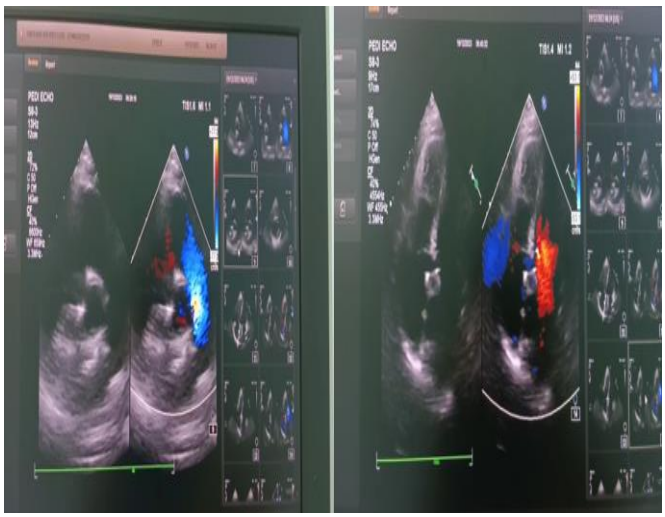

Fig 3 Echocardiography Post ASD Closure

The patients were then followed up at 3 months and 6 months with echocardiography parameters and 6 minute walking test. In echocardiography showed decreased of RV dilatation, increased of LV function. And in 6 mwt showed improvement exercise capacity with increased walking distance, VO2 max , Mets, functional class.

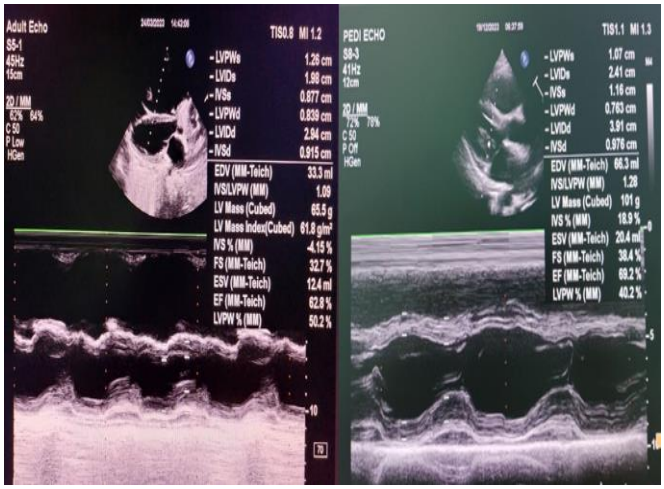

Fig 4 Echocardiography; Increased LV Function

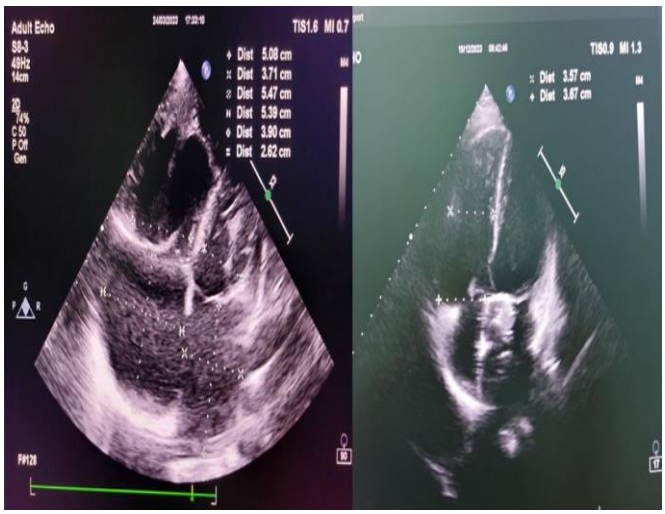

Fig 5 Echocardiography; Decreased RV Dilatation

Table 1 Six MWT; Compare Functional Capacity, before and after ASD Closure

6 MWT Parameters	Before Closure	A day after Closure	3 months after closure	9 months after closure
Walking Distance	420 m	275 m	408 m	435 m
VO2 Max	27,424	18,72	26,392	28,23
Mets	7,83	5,34	7,5	8,06
Fitness Class	I	II	I	I
Functional Class	Fair	Low	Fair	Fair

IV. DISCUSSION

An atrial septal defect (ASD) is a prevalent form of congenital heart defect, affecting approximately 25% of children. An atrial septal defect occurs when the connection between the right and left atria fails to close. It includes abnormalities that affect both the actual septal membrane and additional abnormalities that enable communication between the two atria. The five types of atrial septal defects, listed in order of frequency, are patent foramen ovale, ostium secundum defect, ostium primum defect, sinus venosus defect, and coronary sinus defect. Atrial septal abnormalities of small size typically undergo spontaneous closure throughout childhood. If there are significant abnormalities that do not close on their own, it may be necessary to use percutaneous or surgical methods to intervene and prevent additional consequences like stroke, dysrhythmias, and pulmonary hypertension (Meissner et al., 1999).

Autism Spectrum Disorder (ASD) may go untreated until an individual reaches adulthood. The forms of ASD include Secundum ASD, which accounts for 80% of all ASDs and is located in the region of the fossa ovalis and its surrounding area (Baumgartner et al., 2021):

- Primum ASD, also known as partial AV septal defect or partial AV canal, is a type of atrioventricular septal defect (AVSD) that occurs at the atrial level alone. It is often located near the crux, and it is characterized by malformation of the AV valves, leading to different levels of regurgitation;
- A superior sinus venosus defect is a rare condition, occurring in 5% of cases, where there is a hole around the entry of the superior vena cava (SVC). This defect is often connected with the partial or total connection of the right pulmonary veins to the SVC or right atrium (RA);
- Inferior sinus venosus defect occurs in less than 1% of cases and is located near the opening of the inferior vena cava (IVC);
- A coronary sinus that is not covered by a roof, which occurs in less than 1% of cases, where it is either partially or entirely absent from the left atrium (LA).

The volume of blood shunted relies on the compliance of the right ventricle (RV) and left ventricle (LV), the magnitude of the defect, and the pressure in the left atrium (LA) and right

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atrium (RA). An atrial septal defect (ASD) leads to a left-to-right shunt due to the greater compliance of the right ventricle (RV) relative to the left ventricle (LV). This shunting is typically observed in cases when the defect size is larger than 10 mm. The outcome is an excessive volume load on the RV and increased blood flow to the lungs. A decrease in left ventricular compliance, or any condition that causes an increase in left atrial pressure (such as hypertension, ischemic heart disease, cardiomyopathy, aortic and mitral valve disease), leads to an increase in left-to-right shunting. Therefore, an atrial septal defect (ASD) may become increasingly significant in terms of its impact on blood flow as an individual becomes older. Decreased compliance of the right ventricle (due to conditions such as pulmonic stenosis, pulmonary arterial hypertension, or other diseases affecting the right ventricle) or disease of the tricuspid valve may lead to a decrease in the left-to-right shunt or eventually cause the shunt to reverse, resulting in the presence of cyanosis.

When possible, device closure is now the preferred method for closing secundum defects, mostly due to the morphology of the defect. This includes a stretched diameter of less than 38 mm and a rim of at least 5 mm, save towards the aorta. While it cannot be definitively concluded as zero, multiple recent investigations have documented an absence of mortality. The most favorable result is achieved when the repair is done before the age of 25 years. There is no evidence to suggest that closing an atrial septal defect (ASD) after the age of 40 has any impact on the likelihood of developing arrhythmia throughout the follow-up period. Nevertheless, the patient's morbidity, which includes factors such as exercise capacity, shortness of breath, and right heart failure, can be improved regardless of age with closure, especially if it can be achieved through catheter intervention. Patients diagnosed with pulmonary hypertension (PH) should undergo thorough evaluation with meticulous attention. It is necessary to calculate the PVR. ASD closure has been demonstrated to be safe and is related with a reduction in pulmonary artery pressure (PAP) and relief in symptoms in patients with PVR less than 5 Wood Units (WU).

The follow-up examination should consist of assessing the presence of any remaining abnormal blood flow, the size and functioning of the right ventricle, the tricuspid regurgitation and pulmonary artery pressure using echocardiography. Additionally, the evaluation should involve assessing the presence of any arrhythmias using the patient's medical history, electrocardiogram, and, if necessary, Holter monitoring. Patients who undergo repair before the age of 25 without any lasting complications (such as residual shunt, abnormal pulmonary artery pressure, abnormal right ventricle function, or arrhythmias) do not need to be regularly monitored. Nevertheless, it is crucial to ensure that patients and referring physicians are adequately informed about the potential emergence of tachyarrhythmias at a later stage (Baumgartner et al., 2021).

The exercise capacity of individuals with unrepaired atrial septal defects (ASDs) is determined by several factors, including the significance of the shunt, the function and volume overload of the right ventricle (RV), the level of pulmonary arterial pressure, and the presence of arrhythmias. The exercise capacity of individuals with corrected ASDs is influenced by both the timing of closure and the specific treatment used (either catheter-based or surgical). In patients with Autism Spectrum Disorder (ASD), the function of the right ventricle (RV) may potentially serve as a restricting element. Physiologically, the mean power of the right ventricle (RV) is determined by multiplying the RV cardiac output by the mean pulmonary arterial pressure (mPAP). This value is directly related to the peak oxygen consumption (VO2) during exercise. A greater increase in RV afterload during exercise can negatively impact its function, even in cases of asymptomatic atrial septal defect (ASD) without excessive volume and with normal RV function at rest (Amedro et al., 2018).

In this instance, we have shown that closing an atrial septal defect (ASD) is technically possible and can be successfully achieved. We found a substantial enhancement in symptoms and functional capacity, accompanied by positive changes in the structure and function of the heart. This case exemplified that even though there has been a long-standing enlargement of the right ventricle due to excessive volume, there is still a possibility for the right ventricle to decrease in size and maybe improve in function. The closure of atrial septal defect (ASD) led to cardiac remodeling, resulting in a notable reversal of the volumetric imbalance between the right and left sides of the heart. The effects of these modifications became apparent shortly after the closure and persisted for a period of 9 months (Amedro et al., 2018).

Pascotto et al. have demonstrated that cardiac remodeling initiates soon after transcatheter ASD closure in relatively young people (mean age 22 ±18 years), and the majority of cardiac remodeling occurs within a few weeks of closure. In contrast, the study conducted by Khan et al. on a group of participants with a median age of 68 years found that the majority of the reduction in right ventricle (RV) size occurred more than 6 weeks after the closure of the atrial septal defect (ASD). The closure of the atrial septal defect (ASD) and the reduction of right ventricular volume overflow resulted in an immediate improvement in left ventricular systolic performance. In individuals with an atrial septal defect (ASD), the redirection of blood flow into the right side of the heart consistently impacts the filling of the left ventricle, resembling a "steal phenomenon." The study conducted by Khan et al. provides evidence for the occurrence of ventricular interdependence in cases of right ventricular volume overload. Additionally, the study highlights the occurrence of the "reverse Bernheim's effect," where the septum protrudes into the left ventricular chamber, resulting in poor filling of the left ventricle. After the closure of the device, the flow of blood from the left side to the right side is stopped, and the filling of the left ventricle is enhanced, leading to an augmentation in the size of the left ventricle and the ejection fraction. The enhancement in left ventricular (LV) function was most prominent during the initial 6 weeks following atrial septal defect (ASD) closure, indicating that LV remodeling takes place early on and reaches a plateau thereafter (Khan et al., 2010).

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The enhancement of left ventricular function is expected to be a significant factor in the initial improvement of NYHA functional class observed following ASD closure. The observation is noteworthy that the enhancement in left ventricle (LV) size and function seems to happen earlier compared to the right ventricle (RV). This implies that left ventricle remodeling occurs apart from right ventricle remodeling. There was a reduction in the size of the right ventricle 9 months after closing the atrial septal defect (ASD). Furthermore, alterations were observed in the dimensions of the left ventricle, with an enlargement in the left ventricular end-diastolic volume (LVEDV) and a concomitant rise in the ejection fraction. No instances of pulmonary edema or severe new arrhythmias were seen during the 9-month follow-up period. Furthermore, there were no indications of diastolic dysfunction or mitral regurgitation after the closure of the atrial septal defect (ASD).

This case demonstrates an enhancement in functional class. Patients experienced an increase in walking distance from 420 meters to 425 meters, an improvement in VO2 max from 27,424 to 28,23, and an increase in mets from 7,83 to 8,06 after 9 months of follow-up following ASD closure.

The study conducted by Brochu et al. indicates that there is an early improvement in exercise ability following the operation. A study found that patients who believed they had no symptoms had a VO2max that was 11% lower than what was expected. Even patients with mild left-to-right shunting (Qp:Qs 1.2 to 2.0) had a lower than normal VO2max (83%). This research also found that there was a significant improvement in VO2 max for both the entire group and specific subgroups based on age, functional class, and size of shunt. This improvement was similar to what was observed in a typical exercise training program (Brochu et al., 2002).

A significant enhancement in exercise ability at 6 and 12 months following the surgery (Komar et al., 2015). The duration of exercise within 6 months of ASD closure was significantly longer ($P<0.001$) compared to the initial values, and there was also an increase in oxygen intake. Within just one month after the treatment, a notable reduction in the size of the right ventricle and right atrium was seen, with a statistically significant difference ($P<0.001$) (Nowicki et al., 2021). In this study, it was seen that the right ventricular dimension decreased in 67 patients (89.3%), despite the fact that the population studied was over 60 years old. It is plausible to hypothesize that in a younger population, the ability for improvement may be even greater (Brochu et al., 2002).

V. CONCLUSION

This case report demonstrates that percutaneous ASD closure using the Figulla Flex II device in a young woman with a large secundum ASD and moderate pulmonary hypertension is a safe and effective procedure. The patient experienced significant improvement in symptoms, functional capacity, and cardiac remodeling following closure. Key findings include: Successful closure of the ASD with the Figulla Flex II device; Improvement in symptoms of fatigue and shortness of breath; Increased walking distance and exercise capacity as measured by the 6-minute walk test; Favorable cardiac remodeling with a decrease in right ventricular size and improvement in left ventricular function. This case supports the growing body of evidence that percutaneous ASD closure is a beneficial treatment for symptomatic adults with secundum ASD, even in the presence of moderate pulmonary hypertension. Early intervention may lead to better outcomes, particularly in younger patients with less advanced RV dysfunction.

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