Current and Future Landscape of Structural Heart Interventions

Intervenção Estrutural Cardíaca: Perspetiva Atual e Futura

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Introduction

Structural heart interventions have rapidly become a cornerstone of modern cardiology, representing one of the most transformative aspects of interventional cardiology. This branch of cardiology is driven by technological advancements, a deeper understanding of cardiovascular diseases, and the pursuit of minimally invasive treatment options. The term "structural heart intervention" was originally coined by Dr. Martin Leon in 1999 for the transcatheter cardiovascular therapeutics (TCT) meeting,[1] a prestigious annual event that highlights breakthroughs in interventional cardiology. The term referred to catheter-based procedures that target non-coronary cardiac issues, such as valve diseases, congenital heart defects, and disorders affecting the heart's walls or septum. Historically, such structural issues were managed through open-heart surgery, but the introduction of minimally invasive, catheter-based techniques revolutionized the treatment of these conditions. Dr. Leon recognized early on that advancements in technology and imaging could provide safe, effective alternatives to surgery for many patients, particularly those at high risk for complications from more invasive procedures. Since the introduction of the term, structural heart interventions have gained significant traction, thanks to landmark procedures like transcatheter aortic valve implantation (TAVI), which have provided new treatment avenues for conditions like aortic stenosis. Structural heart interventions have evolved into a critical component of cardiology, addressing a wide range of conditions previously treatable only with surgery. This article, aimed for the non-cardiologist reader, explores the origins, current landscape, and future directions of structural heart interventions, highlighting both the clinical and market implications of this rapidly evolving field.

Understanding Structural Heart Interventions

Structural heart interventions are a subset of interventional cardiology that focuses on treating abnormalities in the heart's anatomy / structure which are non-coronary related. These procedures target issues such as malfunctioning heart valves, septal defects, and congenital abnormalities. Using minimally invasive catheter-based techniques, these interventions allow

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for the repair or replacement of heart structures without the need for traditional open-heart surgery, which involves more risks and longer recovery times.

Some of the most common structural heart interventions include:

a) Transcatheter aortic valve implantation (TAVI): A procedure primarily created to treat aortic stenosis but is currently moving towards the treatment of aortic regurgitation

b) Mitral & tricuspid valve repair/replacement: Procedures designed to correct dysfunction of the mitral or tricuspid valve, either through transcatheter valve repair (e.g. edge-to-edge) or replacement (implantation of a prosthesis in a native or prosthetic valve).

c) Atrial septal defect (ASD) and patent foramen ovale (PFO) Closure: catheter-based procedures to close abnormal openings between the heart's atria, reducing the risk of stroke and other complications (e.g. heart failure, pulmonary hypertension).

d) Left atrial appendage occlusion (LAAO): A procedure to prevent thrombi from forming in the left atrial appendage, reducing the risk of stroke in patients with atrial fibrillation.

These procedures are typically guided by advanced imaging techniques, which help cardiologists visualize the heart's anatomy in real time and guide the catheter to the precise location of the defect.

Advancements and Evolution in Catheterization Laboratories

Over the past two decades, structural heart interventions have dramatically reshaped the landscape of cardiac catheterization laboratories (cath labs). Initially, these labs were predominantly focused on percutaneous coronary interventions (PCI) to treat coronary artery disease. However, the introduction of innovative transcatheter techniques has significantly expanded the scope of procedures performed in cath labs.

Transcatheter aortic valve implantation (TAVI), for example, was initially introduced as an option for high-risk patients with aortic stenosis who were not suitable candidates for open-heart surgery. Since then, its use has expanded to include intermediate and even low-risk patients, marking a paradigm shift in how aortic stenosis is treated. Total number of TAVI procedures have been consistently rising worldwide and in some countries have surpassed isolated surgical aortic valve replacements.[2] This expansion reflects a broader trend toward less invasive, catheter-based treatments across the spectrum of structural heart diseases.

Structural heart interventions increased complexity and demanded new skills. Multidisciplinary teams, designated heart teams, became the standard of care for many of these new procedures. Cardiac surgeons, imaging cardiologists, heart failure specialists, neurologists, anesthesiologists and many others became part of this increasingly heterogeneous units. Training and certification pathways also changed, to adapt to new technical requirements.[3] Management of waiting lists, human resources, back-up intensive care units, follow-up and rehabilitation programs contributed massively to the exponential complexity of the field.

Advances in imaging technology, particularly 3D echocardiography, computed tomography (CT) and cardiac magnetic resonance imaging (MRI), have played a crucial role in the growth of structural heart interventions.[4] These technologies allow cardiologists to visualize the heart in unprecedented detail, improving the precision of transcatheter procedures. Additionally, the use of artificial intelligence (AI) and machine learning in procedural planning has enhanced the accuracy of these interventions, leading to better outcomes and fewer complications.

Emerging Technologies and Therapies

As the field of structural heart interventions continues to evolve, several new technologies and therapies are poised to further revolutionize patient care.

One of the most significant advancements is the continued refinement of transcatheter devices for valve repair and replacement. While TAVI has already transformed the treatment of aortic stenosis, new devices are being developed to address more complex valve diseases, such as mitral and tricuspid valve regurgitation.[5] These conditions have historically been more challenging to treat with transcatheter techniques due to the complex anatomy of the mitral and tricuspid valves. However, novel devices like transcatheter mitral valve replacement and edge-to-edge repair systems are showing promise in clinical trials, offering new hope for patients who were previously deemed inoperable.[6]

In addition to valve interventions, new therapies are being developed to treat other structural heart conditions, such as heart failure and hypertrophic cardiomyopathy.[7] These conditions often require complex, multidisciplinary approaches, and the development of new transcatheter devices has the potential to simplify treatment and improve outcomes.

Furthermore, the integration of AI into procedural planning and execution is expected to further enhance the precision of structural heart interventions. AI algorithms can process vast amounts of data from imaging studies, patient records, and previous procedures to guide cardiologists in real time, improving decision-making and reducing the risk of complications.

Market Implications and Opportunities

The rise of structural heart interventions has not only transformed clinical care but also significantly impacted the market volume of interventional cardiology. As these procedures become more commonplace, they represent a significant portion or even the majority of the revenue generated in cath labs and heart centers worldwide.

The growing demand for structural interventions has prompted healthcare institutions to invest heavily in the necessary infrastructure, training, and technology to support these advanced procedures.

Many hospitals have established dedicated structural heart programs, recognizing the dual clinical and financial value these interventions bring. The aging population and increasing prevalence of valve diseases, heart failure, stroke risk are expected to continue driving demand, making structural heart interventions a key area of growth in interventional cardiology.

Conclusion

Structural heart interventions are at the forefront of modern interventional cardiology, offering less invasive treatment options for various heart conditions and reshaping the landscape of cardiac care. As technological advancements continue to expand the capabilities and applications of these procedures, structural heart interventions are likely to become even more integral to cardiology practice. The field's future will depend on ongoing innovation, training, and ethical considerations to ensure these benefits are accessible to a broad patient population.

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