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MITRAL VALVE PATHOLOGY: CHALLENGES AND SOLUTIONS – A SHORT OVERVIEW

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Abstract

Mitral valve prolapse (MVP) is the most common valve disease (prevalence of 2 to 3%). Although MVP is generally regarded as a benign condition, complications such as mitral regurgitation, atrial fibrillation, congestive heart failure, endocarditis and stroke are well known. MVP is a significant cause of SCD where CE-CMR (contrast-enhanced MRI) might allow the identification of this arrhythmic substrate.

Transcatheter mitral valve interventions are progressively being introduced into clinical practice targeting a population of patients with mitral regurgitation (MR). Beyond percutaneous edge to edge repair (MitraClip®), a percutaneous surgical-like direct annuloplasty device but also transcatheter chordal replacement and indirect annuloplasty (using coronary sinus devices, radiofrequency-mediated annular remodeling and cinching devices) are in various stages of development. Meanwhile, we do have personal experience using Melody valves as MV replacement using the hybrid approach.

Rheumatic fever continues to be the commonest cause of acquired heart disease in the children and adolescent population of most developing countries. Until the early 1980s, the only option for patients with mitral stenosis (MS) uncontrollable by medical therapy was surgery. After several technical modifications balloon mitral valvotomy is a standard therapeutic modality for managing rheumatic mitral stenosis. Patients with sinus rhythm, less gross valve deformity, and a post-balloon mitral valvotomy area >1.75 cm² will have better intermediate outcomes. Detailed knowledge of MV pathology will lead to perfect solutions for each individual patient.

Key words: mitral valve, pathology, challenges.

Introduction

The mitral valve connects the left atrium (LA) and the left ventricle (LV) and is located obliquely behind the aortic valve. The normal function of the mitral valve depends on its 6 components, which are the left atrial wall, the annulus, the leaflets, the chordae tendineae, the papillary muscles, and the left ventricular wall (1). Any congenital or acquired disorder of individual components can disturb the finely coordinated mechanisms of the mitral valve and result in an incompetent valve, where the left atrial myocardium extends over the proximal portion of the posterior leaflet. Thus, left atrial enlargement may result in mitral regurgitation by affecting the posterior leaflet. The anterior leaflet is not affected, because of its attachment to the root of the aorta (1). The mitral annulus is a fibrous ring that connects with the leaflets. It is not a continuous ring around the mitral orifice and appears to be more D-shaped, rather than circular. The annulus functions as a sphincter that contracts and reduces the surface area of the valve during systole to ensure complete closure of the leaflets. Thus, annular dilatation of the mitral valve causes poor leaflet apposition, which results in mitral regurgitation (2). The free edges of the leaflets have several indentations. Two of these indentations, the anterolateral and posteromedial commissures, divide the leaflets into anterior and posterior. Normally, the leaflets are thin, pliable, translucent, and soft with an atrial and a ventricular surface. The anterior leaflet is located posterior to the aortic root and is also known as the aortic, septal or anteromedial leaflet. The posterior leaflet is also known as the ventricular, mural or posterolateral leaflet and is divided into 3 scallops by 2 indentations or clefts (3).

The chordae tendineae are small fibrous strings that originate either from the apical portion of the papillary muscles or directly from the ventricular wall and insert into the valve leaflets or the muscle. These 2 types are called true chordae tendineae and false chordae tendineae, respectively. The papillary muscles normally arise from the apex and middle third of the left ventricular wall. The anterolateral papillary muscle is normally larger than the posteromedial papillary muscle and is supplied by the left anterior descending artery or the left circumflex artery. The posteromedial papillary muscle is supplied by the right coronary artery (4).

Mitral valve pathology

Mitral valve prolapse

MVP is defined as mitral leaflet billowing by more than 2mm above the anterior and posterior edges of the mitral annulus during ventricular systole (5). Mitral regurgitation is due to a combination of leaflet and chordal extensibility and elongation probably together with superior papillary muscle displacement or traction (6, 7). The billowing leaflets may appear diffusely thickened (“Barlow’s syndrome”) or thin except in flail portions (“Fibroelastic deficiency”). Repair strategies aim to restore effective leaflet coaptation by reducing leaflet redundancy and mitral annular dimensions, and if needed implanting artificial chordae. Suitable mitral valve leaflet characteristics may also allow leaflet free edge approximation at the site of regurgitation (edge-to-edge technique) by a stitch or a clip (MitraClip). Repair techniques, pioneered by Alain Carpentier, aim to restore leaflet function while preserving the native valve. Mitral valve replacement is not commonly indicated with a skilled surgeon (8).

Functional/Ischemic Mitral Regurgitation

Functional or ischemic MR is caused by displaced papillary muscles in the setting of a distorted, remodeled LV with increased distance between PM heads and mitral annulus and inadequate leaflet coaptation. Global LV dilatation restricts systolic closure motion of the MV leaflets.

Repair strategies aim to restore LV shape and function, PM approximation (8), chordal cutting, leaflet edge-to-edge approximation technique (9, 10), mitral annulus area reduction or valve replacement. However, therapy strategies that deal with the annulus, but not the ventricular tethering are often limited, with recurrent MR (11) which can be reduced by chordal cutting.

MVR in the case of Hypertrophic cardiomyopathy

HCM is an autosomal dominant disease of myocyte disarray and fibrosis, morphologically characterized by significant LV hypertrophy in the absence of chronically elevated afterload or infiltrative diseases (12). HCM involves the papillary muscles and mitral leaflets:

The PMs are anteriorly displaced and the heads positioned closer to each other (13) displacing the anterior leaflet into the LV outflow tract. If anterior leaflet displacement is severe enough to impair posterior leaflet apposition, mitral regurgitation will occur (14). Since PM position is the main

mechanism, septal reduction therapy does not always eliminate SAM (15). Because of these mechanisms, repair strategies include papillary muscle repositioning and reducing leaflet redundancy.

Special Issues

Arrhythmogenic mitral valve prolapse

Mitral valve prolapse (MVP) is a common valvular abnormality with a prevalence of approximately 2–3% in the general population (16). Prospective studies, however, report sudden cardiac death (SCD) rates of 0.2–0.4% per year, approximately twice that of the general population (17). Among sudden death survivors the prevalence of bileaflet MVP (BiMVP) is high with a common clinical tetrad of 1) BiMVP, 2) female gender, 3) T wave abnormalities (biphasic or inverted T waves), and 4) complex ventricular ectopy (multi-form premature ventricular complexes, ventricular bigeminy, ventricular tachycardia [VT], or ventricular fibrillation [VF]) (18). More recently, however, Nordhues et al. showed that BiMVP is associated with an increased risk of ventricular tachycardia but, overall, does not appear to portend a poor prognosis at the population level when compared to patients with SiMVP or controls without MVP (19). Although the mechanism for proarrhythmia in MVP is not completely understood, mechanical stress on the papillary muscles resulting in fibrosis is a likely contributor (20). Han et al. demonstrated increased late gadolinium enhancement on cardiac magnetic resonance imaging (MRI) suggestive of fibrosis in the papillary muscles adjacent to the chordae tendineae in MVP patients with complex ventricular arrhythmias (21). Chesler et al. reported endocardial friction lesions suggesting mechanical contact from the prolapsing leaflets also likely plays a role (22).

Rheumatic mitral valve disease

The prevalence of rheumatic fever has declined significantly in most of the developed world. It continues, nonetheless, to be the commonest cause of acquired heart disease in the children and adolescent population of most developing countries (23). Rheumatic mitral stenosis (MS) developing as a sequel of rheumatic fever causing thickening and fibrosis of the mitral valve apparatus is still an important cardiac morbidity in developing nations. Balloon mitral valvotomy (BMV) has been considered the standard therapeutic modality since its introduction, as an alternative to surgical mitral commissurotomy or valve replacement (24). Most published series have reported

an immediate success rate of over 90% with balloon dilatation in children and young adults. These gratifying results are also reported from very young children of less than 12 years of age (25). The complications, seen in about 1% to 2% of cases, include development of significant mitral regurgitation and hemopericardium, secondary to cardiac chamber perforation. The long-term results indicate slightly higher restenosis rates in children than in adults. Most children with restenosis can undergo successful repeat dilatation (26).

Transcatheter mitral valve interventions

Mitralstenosis

All symptomatic patients of mitral stenosis with significant stenosis should be considered for percutaneous transvenous mitral commissurotomy (27). Since 1984 the use of the Inoue balloon has gained widespread acceptance. This balloon changes shape in three stages, depending on the extent of inflation. It is inserted from the saphenous vein into the mitral orifice transseptally, fixed across the mitral orifice with partial inflation, and finally inflated to its full extent, separating the fused commissures by its expansile force (28). It is recommended to start with a smaller balloon size and increase its size in a stepwise fashion to minimize complications. Detailed technical information are provided by Arora et al (27).

Mitral Regurgitation

Among the transcatheter MV repair technologies, edge-to-edge MV repair with the MitraClip system (Abbott Vascular, Abbott Park, IL, USA) has undergone the most extensive human investigation thus far, with more than 20,000 procedures already performed (29). In children however, percutaneous edge-to-edge mitral valve repair has been used extremely rarely (30). The same is true for indirect (The Carillon Mitral Contour System (Cardiac Dimension, Inc, Kirkland, WA, USA)) and direct transcatheter annuloplasty technologies (The Mitralign Percutaneous Annuloplasty System (Mitralign, Tewksbury, MA, USA) or The Cardioband System (Valtech Cardio Ltd, Or Yehuda, Israel)).

Surgical approach

Surgical repair is the reference standard treatment in primary MR. Percutaneous intervention in MR should currently be reserved for high-risk or inoperable patients. Mitral valve repair can be achieved using a variety of isolated

or combined techniques such as leaflet resection, implantation of artificial chordae, chordal transposition/transfer, edge-to-edge technique, annuloplasty using a prosthetic ring or band (31). In the case of rheumatic mitral valve regurgitation, initial experiences showed less good results after repair of rheumatic than with degenerative valves. However, Talwar et al. have similarly produced excellent results in children with a mean age of 11 years, having observed a 90% survival and up to 15 years of follow-up (32).

In secondary MR, medical therapy is the first choice, the role of surgery is controversial, particularly when concomitant revascularization is not an option, owing to significant operative mortality, high rates of recurrent MR, and absence of proven survival benefit (33).

Conclusion

Mitral valve pathophysiology and the resulting diagnostic and treatment options are complex. A detailed knowledge of MV pathology and high level of personal skill and experience will lead to a perfect solution for each individual patient.

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PATOLOGIJA MITRALNOG ZALISKA: IZAZOVI I RJEŠENJA – KRATAK PREGLED

Sažetak

Prolaps mitralnog zaliska (MVP) je najčešća bolest zaliska (prevalencija 2 do 3%). Iako se MVP generalno smatra benignim stanjem, dobro su poznate komplikacije kao što su mitralna regurgitacija, atrijske fibrilacije, kongestivno zatajenje srca, endokarditis i srčani udar. MVP je značajan uzročnik iznenadnog zastoja srca, gdje CE-CMR (kontrastni-MRI) može omogućiti identifikaciju ovog aritmijskog substrata.

Transkateterske intervencije mitralnog zaliska se postepeno uvode u kliničku praksu cilja-jući populaciju bolesnika s mitralnom regurgitacijom (MR). Mimo perkutanih edge-to-edge popravki (MitraClip®), u različitim fazama razvoja su i perkutani uređaj za direktnu anuloplastiku sličnu hirurškoj, te transkateterska zamjena hordi i indirektna anuloplastika (uz korištenje uređaja za koronarni sinus, anularno remodeliranje uz korištenje radiofrekvencije i uređaje za sužavanje - cinching). U međuvremenu, imamo i lično iskustvo u korištenju Melody ventila kao zamjene za MV uz primjenu hibridnog pristupa.

Reumatska groznica i dalje je najčešći uzročnik stečene bolesti srca u populaciji djece i adolescenata u većini zemalja u razvoju. Prije ranih 1980-ih, jedina opcija za pacijente s mitralnom stenozom (MS) koja se nije mogla kontrolisati medicinskom terapijom bila je operacija. Nakon nekoliko tehničkih modifikacija, balonska mitralna valvulotomija je standardni terapijski model za upravljanje reumatske mitralne stenozе. Pacijenti sa sinusnim ritmom, manjim deformitetom ventila i područjem mitralne valvulotomije $> 1.75 \text{ cm}^2$ nakon balona će imati bolje srednjoročne rezultate.

Detaljno poznavanje MV patologije će dovesti do savršenog rješenja za svakog pojedinog pacijenta.

Ključne riječi: mitralna valvula, patologija, izazovi