MANAGEMENT OF PATIENTS WITH VALVULAR HEART DISEASE

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Rheumatic fever and rheumatic heart disease remain major clinical and public health problems in developing countries where their most devastating effects are on children and young adults in their most productive years. RHD is encountered in 1 to 5.4 per 1,000 in large samples of school children and RF in 0.3 to 0.5 per 1,000 children. Rheumatic valve heart disease accounts for 2.2 per 1000 deaths and disability adjusted life years in south central Asia (Carapetis et al 2000). Mild to moderate degree of valvular heart disease are relatively common in adults, increase in prevalence with advancing age, and are associated with reduced survival.

Two major questions must be answered in the management of every case with valvular heart disease.

1. Is the valvular heart disease severe enough to cause morbidity and mortality for which mechanical intervention would be beneficial?

2. And if the answer to this question is yes, what are the best time for surgical/ catheter intervention to minimize or eliminate morbidity and mortality?

We will discuss these questions for major acquired and congenital valvular diseases affecting left and right side of heart.

MITRAL STENOSIS:

The most frequent cause of MS is chronic rheumatic carditis, sequelae of one or more prior episodes of acute rheumatic fever. Acquired causes of mitral valve obstruction, other than rheumatic heart disease, are rare and include left atrial myxoma, ball valve thrombus, mucopolysaccharidosis, and severe annular calcification.

Echocardiography is the cornerstone in the evaluation of suspected or known MS to confirm the diagnosis, evaluate the severity and assess suitability for balloon mitral valvotomy. The diagnostic features of rheumatic mitral valve disease are leaflet thickening and decreased mobility, commissural fusion, and involvement of the subvalvular apparatus.

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean gradient (mmHg)*</td>
<td>&lt;5</td>
<td>5-10</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Pulmonary artery pressure (mmHg)</td>
<td>&lt;30</td>
<td>30-50</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Valve area (cm²)</td>
<td>&gt;1.5</td>
<td>1.0-1.5</td>
<td>&lt;1.0</td>
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</table>

*Valve gradients are flow dependent and when used as estimates of severity of valve stenosis should be assessed with knowledge of cardiac output or forward flow across the valve.

CLASSIFICATION OF THE SEVERITY OF MITRAL STENOSIS

Assessment of Valve Morphology

Valvular and subvalvular lesions are usually combined in scores. Wilkins and Cormier score can be used to assess feasibility for BMV (balloon mitral valvuloplasty). (However both these score do not describe commissural calcification). Accurate assessment of associated MR by different quantitative and semiquantitative methods is important, as it has implications on choice of type of intervention.
Transesophageal echocardiography (TEE) has a much higher sensitivity than transthoracic echocardiography for detecting left atrial thrombus particularly in the left atrial appendage.

**Medical management:**

The goals of medical therapy are to prevent rheumatic fever, to improve symptoms, and to decrease the thromboembolic risk. Although painful, intramuscular injection of benzathine penicillin every 3 weeks has the advantage of better compliance than daily oral treatment, particularly in young patients and in developing countries. Diuretic and beta blockers are useful in symptomatic patients for treating failure and rate control. In patients with MS and atrial fibrillation, restoration of sinus rhythm is superior to rate control to improve indices of functional capacity and quality of life. When atrial fibrillation cannot be converted in sinus rhythm, rate control is obtained using digitalis and/or β-blockers. Anticoagulation is indicated for patients in atrial fibrillation, those with large LA, or prior embolism.

**BalloOn Mitral Valvuloplasty (BMv)**

The application of BMV depends on three major factors: the patient’s clinical condition; valve anatomy, and the experience of the medical and surgical teams of the institution concerned. BMV is indicated in all symptomatic patients with suitable valve, asymptomatic patients with PA pressure more than 50 or exercise induced symptoms.

The European guidelines do not fix a threshold for systolic pulmonary pressure on exercise but recommend performing BMV if symptoms appear during exercise. Indications for performing balloon mitral valvulotomy in asymptomatic patients are pulmonary arterial hypertension, episodic pulmonary edema & when contemplating future pregnancy. BMV can be performed safely in pregnancy after 20th week with radiation protection shield.

Mitrail regurgitation grade 2 or less, unicommissural calcium and LAA thrombus are not contraindication for BMV. In some patients MR may reduce after successful BMV.

Indications for MVR in severe mitral stenosis are presence of LA body thrombus, severe or bicommissural calcification, severe associated aortic or tricuspid valve disease, associated coronary artery disease requiring CABG. Metallic valve is usually preferred because of better durability and requirement of long term anticoagulation in patients with atrial fibrillation.

CMC (closed mitral commissurotomy) is rarely performed in era of intervention. OMC (open mitral commissurotomy) may be done in patients with isolated severe mitral stenosis with large LA clot.

**TREATMENT STRATEGY**

In current practice, percutaneous intervention has almost replaced surgical commissurotomy. Surgery is the only alternative when BMV is contraindicated.

In treatment of MS, BMV and valve replacement must be considered not as rivals but complementary techniques, with each applicable at the appropriate stage of the disease.

**INDICATIONS FOR BALLOON MITRAL COMMIS- S UROTY M IN PATIENTS WITH MITRAL STENO- SIS**

*American College of Cardiology/American Heart Association guidelines*^7^
Progressive increase in LV volume is compensated by increase in cardiac output. Once LV compliance reduces, LVEDP rises and symptoms ensue. Hence, even mild reduction in LVEF in a patient with MR is significant. Patients with severe MR are usually asymptomatic for long duration. Even mild symptoms indicate that significant LV dysfunction is present.

**Echocardiographic criteria for mitral regurgitation:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mild</th>
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</tr>
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<tbody>
<tr>
<td>Colour Doppler jet area</td>
<td>Small, central jet,(&lt;20% of LA area)</td>
<td>MR-mild, but no criteria for severe MR (&lt;40% of LA area)</td>
<td>Large, central jet (&gt;40% of LA area)</td>
</tr>
<tr>
<td>Doppler vena contracta (cm)</td>
<td>&lt;0.3</td>
<td>0.3-0.69</td>
<td>≥0.7</td>
</tr>
<tr>
<td>Regurg. Volut. (ml)</td>
<td>&lt;30</td>
<td>30-59</td>
<td>≥60</td>
</tr>
<tr>
<td>EROA(cm2)</td>
<td>&lt;0.2</td>
<td>0.2-0.39</td>
<td>≥0.4</td>
</tr>
<tr>
<td>Regurg. Fract.</td>
<td>&lt;30</td>
<td>30-49</td>
<td>&gt;50</td>
</tr>
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</table>

(ER0A-effective regurgitant orifice area.)

**Medical Therapy**

Aggressive medical treatments with the combination of β-blockers and ACE inhibitors have shown beneficial effects on LV remodeling and MR. There are no published data from large trials regarding whether attenuation of remodeling by ACE inhibitors or angiotensin receptor blockers decreases the post-MI incidence of ischemic MR.

**MANAGEMENT OF PATIENTS WITH SEVERE MITRAL REGURGITATION**

(American College of Cardiology/American Heart Association guidelines)

**Acute Mitral Regurgitation**

Acute mitral regurgitation is usually due to an acute structural problem of the mitral valve apparatus, either infection causing destruction of the mitral valve leaflets or chordae, spontaneous chordal rupture, or papillary muscle rupture from a myocardial infarction or as a complication of BMV (balloon mitral valvuloplasty). IABP (intraaortic balloon counterpulsation) may be used to stabilize the patient. Emergency mitral valve replacement is definitive treatment.

**Percutaneous transcatheter treatment of mitral regurgitation**

Patients with symptomatic MR face significant risk inherent to the operative procedure, particularly when comorbid conditions are present. In an effort to develop less invasive treatment options and to avoid cardiopulmonary bypass for mitral valve repair or replacement, efforts have recently focused on the development of transcatheter techniques that mimic current surgical approaches.

Concept underlying development of the mitralclip device (Evalve, Menlo Park, CA) is making double orifice mitral valve that is not stenotic and effectively reducing MR, through a transcatheter approach. (Alfieri repair analog). Percutaneous repair of MR, using Evalve mitral clip device has been shown to be safe and effective. Various devices used are Evalve, Manlo Park and CA.

**EVEREST II** a randomized clinical trial tested the safety and efficacy of the MitraClip device compared to the current gold standard of surgical mitral valve repair or replacement. One-year findings indicated similar MR reduction and similar rates of death with the MitraClip device compared to surgery. It has not been approved by FDA and is still in trial phase.

**Coronary sinus devices:**

Device placed in coronary sinus that could either cinch or compress the coronary sinus or directly move it forward should also move the posterior leaflet toward the anterior
leaflet. This would reduce the MR in patients in whom the line of coaptation was separated.

These devices are in early clinical trials. (Viacor PTMA device, Carillon Mitral contour device, MONARC device). These are useful in patients with annular dilation.

Retrograde transventricular mitral annuloplasty and Left atrial device are newer approaches for reducing ischemic MR secondary to malaligned leaflets.

AORTIC STENOSIS

Valvular aortic stenosis is gradually progressive disease and patients remain asymptomatic for many years. Aortic stenosis is narrowing of aortic valve orifice, caused by failure of the valve leaflets to open normally. This reduction in orifice area produces an energy loss as laminar flow is converted to less efficient turbulent flow, in turn increasing the pressure work that the left ventricle must perform to drive blood past the narrowed aortic valve. The concentric left ventricular hypertrophy that develops as a major compensatory mechanism helps LV cope with the increased pressure work it must perform. These factors – turbulence, energy loss and hypertrophy—constitute the pathophysiologic underpinnings of patient’s symptoms.

First symptom of valvular aortic stenosis is decreased exercise tolerance. Exertional angina and exertional syncope are the other two classical symptoms.

Clinical outcome in asymptomatic patients

Patients with congenital AS tend to become symptomatic in early childhood or adolescence; particularly patients with unicuspid valve tend to present with early symptoms and is most common cause of fatal valvular AS in children <1 year of age. Patients with congenital bicuspid valve develop symptoms during 3rd to 5th decade. Patients with rheumatic aortic stenosis always have associated mitral valve involvement and present in 3rd to 5th decade of life. In adult patient with degenerative calcific valve disease, symptom onset occurs in elderly patients’ aged 70-90 years.17-19

Natural history of aortic stenosis20

Echocardiography:

Most clinically useful measures of stenosis are maximum jet velocity, mean pressure gradient (highly flow dependent) and continuity equation valve area (less flow dependent).

Stenosis severity by echocardiography

<table>
<thead>
<tr>
<th>Stenosis severity</th>
<th>V max (m/s)</th>
<th>Mean P(mm Hg)</th>
<th>AVA cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild *</td>
<td>&lt;3</td>
<td>&lt;25</td>
<td>&gt;1.5</td>
</tr>
<tr>
<td>Moderate</td>
<td>3-4</td>
<td>25-40</td>
<td>1-1.5</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt;4</td>
<td>&gt;40</td>
<td>&lt;1</td>
</tr>
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</table>

Patients with severe AS, falsely low gradient and LV dysfunction, dobutamine stress echocardiography can distinguish patients with preserved contractile reserve.

Increase in stroke volume of >20% has been shown to be a potent predictor of outcome. Even in patients with low flow, low grade aortic stenosis survival in surgical group is better than in non-surgical group (78% vs. 15%).21

SURGICAL INTERVENTION AND POSTOPERATIVE OUTCOME

Timing of Surgical Intervention

Symptomatic patient

If severe aortic stenosis is present by echocardiography or catheterization, even mild symptoms should be considered to be due to aortic stenosis, and the patient should be referred promptly for surgical intervention.

Surgery in Asymptomatic Patients7

Patients with notably calcified valves who have in addition increase in transaortic velocity of 0.3 m/s or greater during a year should be considered for surgery. (ACC/AHA class IIb)

Patient with moderate/severe AS undergoing CABG or other valvular surgery should undergo AVR (ACC/AHA class IIa).

Even patients with mild AS should be considered for AVR when undergoing CABG.22,23

Valve replacement remains procedure of choice even in elderly patients.24

Management strategy for patients with severe aortic stenosis

(American College of Cardiology/American Heart Association Guidelines)7

<table>
<thead>
<tr>
<th>Severe Aortic Stenosis</th>
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</thead>
<tbody>
<tr>
<td>Vmax greater than 4 m/s</td>
</tr>
<tr>
<td>AVA less than 1.0 cm²</td>
</tr>
<tr>
<td>Mean gradient &gt; 40 mm Hg</td>
</tr>
</tbody>
</table>

Undergoing CABG or other heart surgery?

Symptoms?

Yes

Severe valve calcification, rapid progression, and/or expected delays in surgery

No

Class I Class I Class I Class IIb Class IIb

Aortic Valve Replacement

Clinical follow-up, patient education, risk factor modification, annual echo

Preoperative coronary angiography

Equivocal

Normal

Exercise test LV ejection fraction

Symptomatic

No

Yes

Aortic Valve Replacement

Preoperative coronary angiography

Re-evaluation

No

Clinical follow-up, patient education, risk factor modification, annual echo
Aortic balloon Valvuloplasty:

Procedure is recommended in patients with congenital, non-calcific bicuspid aortic stenosis. Procedure produces no regression in ventricular hypertrophy and gradient is reduced acutely by 50%. It should be regarded as palliative procedure or as a ‘bridge to surgery’ in severely symptomatic patients who need time to recover from other illness prior to aortic valve surgery.25,26

Prevention of Disease Progression

Four retrospective studies reported significantly slower rates of hemodynamic progression in patients with AS receiving treatment with statins.27-30 The rate of hemodynamic progression was unrelated to cholesterol levels, among both the statin-treated and the untreated patients. These findings initiated the hypothesis that the effects of statins at the valvular level may be caused by their pleiotropic or anti-inflammatory properties rather than by their cholesterol-lowering effect.

The Scottish Aortic Stenosis and Lipid Lowering Trial, Impact on Regression (SALTIRE) trial, which was the first prospective study to randomly assign patients with aortic stenosis to receive placebo or 80 mg of atorvastatin yielded a negative result after a mean follow-up of 26 months. The major difference with this study, however, was that patients who actually had hyperlipidemia were excluded as it was judged to be unethical to deprive these patients of statin therapy.31

In the SEAS trial,32 there were fewer ischemic cardiovascular events in the treatment arm than in the placebo group (15.7% versus 20.1%, p=0.02) with a significantly lower incidence of the necessity for coronary artery bypass grafting in the treated patients.

Thus, statin treatment is recommended to prevent increased CV mortality in patients with aortic stenosis, as well as to retard the progression of valvular stenosis irrespective of the lipid levels.

Percutaneous Aortic Valve Implantation:

Currently, open surgical aortic valve replacement (or repair in rare instances) is the most commonly used modality and offers excellent long-term results, however approximately one third of patients with symptomatic aortic stenosis are denied traditional surgery.

Candidates for percutaneous aortic valve implantation have primarily included patients with a contraindication to or high risk for surgical aortic valve replacement. These are trileaflet bioprosthetic valve mounted in a wire mesh that can be crimped to allow delivery through a catheter. Two types of aortic valves for percutaneous implantation have been used in a significant number of patients: balloon-expandable and self-expanding.

Percutaneous aortic valve implantation was successful in more than 90% of patients in recent series. Medium term outcomes after transcatheter percutaneous aortic valve implantation (TAVI) show good hemodynamic and clinical results.

Indications: Severe symptomatic valvular aortic stenosis with one or more of following

High risk for conventional AVR (EuroScore >20%, Society of Thoracic Surgeons score >10)

Porcelain aorta

Previous (multiple) thoracotomies

Severe pulmonary disease

Cirrhosis of liver

Contraindications to TAVI include patients with too large or small annulus for prosthesis, patients with severe iliofemoral disease and patient in whom AVR can be done at acceptable risk.

The PARTNER33 trial was designed to compare the safety and efficacy of TAVI (either transfemoral or transapical) to surgical AVR in high-risk, operable patients with symptomatic, severe aortic stenosis.

The investigators concluded that TAVI is an acceptable alternative to AVR in selected high-risk operable patients with severe aortic stenosis.

The composite outcome of all-cause mortality or stroke did not differ between groups at 1 year (26.5% and 28.0%; p=0.70). However, major strokes and vascular complications were commoner with TAVI and major bleeding complications were commoner with surgical AVR. Paravalvular regurgitation was common in TAVI group.
AORTIC REGURGITATION:

Congenital or acquired deformities of the valve cusps or commissures and dilatation, distortion, or enlargement of the aortic root and ascending aorta are often the underlying causes. In developing countries, a rheumatic etiology predominates, whereas in most developed nations, the most common cause is aortic root dilation or a congenitally bicuspid aortic valve. Indications for aortic valve replacement include development of (a) symptoms, (b) left ventricular systolic dysfunction, (c) excessive left ventricular dilatation, and/or (d) severe dilatation of the aortic root or ascending aorta.

In patients with AR due to enlargement of the aorta or aortic root, the natural history of the disease and thus the timing and choice of surgical intervention are often based on the degree and rate of aortic or aortic root dilatation rather than on the left ventricular response to aortic regurgitation.

Echocardiographic criteria for aortic regurgitation:35

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<td>Large, central jet width (&gt;65% of LVOT area)</td>
</tr>
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<td>Doppler vena contracta (cm)</td>
<td>0.3</td>
<td>0.3-0.6</td>
<td>≥0.6</td>
</tr>
<tr>
<td>Regurg. Volum. (nl)</td>
<td>&lt;30</td>
<td>30-59</td>
<td>≥60</td>
</tr>
<tr>
<td>EROA (cm2)</td>
<td>&lt;0.1</td>
<td>0.1-0.29</td>
<td>≥0.3</td>
</tr>
<tr>
<td>Regurg. Fract.</td>
<td>&lt;30</td>
<td>30-49</td>
<td>&gt;50</td>
</tr>
<tr>
<td>Additional essential criteria</td>
<td>LV size</td>
<td>Increased</td>
<td></td>
</tr>
</tbody>
</table>

Exercise testing: Assessing functional capacity and symptomatic response in patients with equivocal symptoms. Reduced maximal oxygen consumption and aerobic threshold are also predictive of moderate to severe LV dysfunction. Increase in radionuclide EF with exercise of at least 5 EF units correlates with preserved LV function, whereas any decrease or increase of less than 5 EF units indicates elevated end systolic wall stress.

In patients with indeterminate echocardiographic findings CMR is a reliable tool for assessment of severity of AR. CMR is an excellent tool to monitor LV volume with high degree of interobserver reproducibility.

Medical management: Role of vasodilator therapy

Vasodilators are useful in patients with severe AR and symptoms and/or LV dysfunction who are considered poor candidates for surgery because of severe comorbidities. Vasodilators are also useful for improving the hemodynamic profile in patients with severe heart failure symptoms before AVR. The role of vasodilator therapy in asymptomatic chronic severe AR is controversial and a recent study failed to demonstrate benefit of such therapy.34

If such therapy is used in asymptomatic patients with severe AR, the goal should be to reduce systolic blood pressure, and drug dosage should be increased until a measurable decrease in blood pressure is achieved.

Indications for Surgery:

The surgical management in AR usually requires AVR. In younger patients, some groups use the pulmonic autograft procedure (the Ross procedure).

Preoperative predictors of patient outcome and LV function after AVR are functional class, EF, and end-systolic dimension.

In symptomatic patients with decreased LV systolic function (subnormal EF), surgery is definitely indicated.

Surgery should also be considered in asymptomatic patients with severe AR and impaired LV function at rest, defined as resting EF less than 50% and/or extreme degrees of LV dilatation (end-diastolic diameter ≥70 to 75 mm and end-systolic diameter ≥50 to 55 mm).

In patients with AR undergoing other cardiac operations, such as coronary bypass surgery or mitral valve surgery, the decision to replace the aortic valve should be individualized according to the severity of AR, age, and overall clinical situation.

Management of patients with severe aortic regurgitation:7

(American College of Cardiology/American Heart Association Guidelines)

Chronic Severe Aortic Regurgitation


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**Concomitant Aortic Root Disease:**

Timing and choice of surgical intervention are often based on the degree and rate of aortic or aortic root dilation rather than on the LV response to AR.

These patients include patients with Marfan syndrome, patients with bicuspid aortic valves, and patients with annuloaortic ectasia. In patients with Marfan syndrome, β-blockers slow the progression of aortic dilatation. Losartan has been shown to reduce aortic root dilatation in patients with Marfan syndrome. Aortic root dilatation greater than 55 mm should be considered a surgical indication irrespective of the degree and etiology of AR. In patients with Marfan syndrome or bicuspid valves, lower degrees of root dilatation (>45 and >50 mm, respectively) have been proposed as indicators for surgery, especially when there is a rapid increase in aortic diameter between serial measurements (5 mm per year) or a family history of aortic dissection.

**ACUTE AORTIC INSUFFICIENCY:**

Acute severe insufficiency is usually a surgical emergency. Large regurigitant volume entering the LV causes sudden rise in LVEDP and acute pulmonary congestion.

Also, reduced output in concert with elevated LV pressure causes reduced coronary perfusion and ischemia. Important clues on physical examination are soft S1 and blowing murmur of AR. AVR should be contemplated in any patient with acute aortic insufficiency who has evidence of even mild congestive heart failure or mitral valve preclosure.

**TRICUSPID REGURGITATION:**

The patient's clinical status and etiology of the tricuspid valve abnormality usually determine the appropriate therapeutic strategy.

*Functional tricuspid regurgitation (TR)* due to pulmonary hypertension is seen in patients with significant left-sided heart disease, commonly rheumatic in origin, those with primary pulmonary hypertension, and those with pulmonary disease leading to cor pulmonale, while *organic TR* is secondary to leaflet affection (congenital or acquired) or secondary to annular dilatation. At systolic PA pressure above 55 mm Hg, significant functional TR occurs which is reversible if annulus in not significantly dilated.

*Timing and type of Surgery*

Tricuspid valve surgery is the only demonstrated effective treatment for symptomatic tricuspid valve regurgitation. Tricuspid valve surgery is recommended in symptomatic patients, those undergoing surgery for other valves and in those with progressive dilated RA and RV. Tricuspid valve repair with an annuloplasty ring is associated with better long-term event-free survival and freedom from recurrent tricuspid regurgitation than simple purse-string annuloplasty alone.

Tricuspid valve replacement is indicated for patients with symptomatic tricuspid regurgitation and pulmonary hypertension or for patients who have abnormal tricuspid valves not amenable to repair. When there is marked annular dilatation, tricuspid valve replacement should be considered rather than repair. Bioprosthetic valve is preferred to metallic ones, as they do not require long term anticoagulation.

Pericardial bioprostheses are not usually placed in the tricuspid position because of their increased leaflet stiffness and risk of obstruction.

**TRICUSPID STENOSIS**

Tricuspid stenosis is uncommon lesion, is usually rheumatic in origin and almost exclusively accompanies mitral stenosis. Other causes include carcinoma, RA myxoma and metastatic tumors. Tricuspid stenosis that requires surgery is most commonly due to rheumatic heart disease and is best treated by valve replacement.

Tricuspid balloon valvotomy has been advocated for tricuspid stenosis of various causes. However, severe TR is a common consequence of this procedure, and results are poor when severe TR develops.

**PULMONIC STENOSIS**

Pulmonic valve stenosis is related to a congenital or genetic disorder in 95% of patients. Although pulmonic stenosis may be a feature of complex congenital cardiac lesions, such as tetralogy of Fallot, 80% of cases occur in isolation.

Evaluation of valve morphology is important as dysplastic valves respond poorly to balloon dilation. The pulmonary annulus and outflow tract may also be narrowed; this type of valve morphology is common in patients with Noonan syndrome.

Echo criteria for severity classify mild as peak gradient <36, moderate 36–60 and severe >60 mm Hg.

Balloon valvuloplasty is the procedure of choice for children and adults with severe or symptomatic pulmonic stenosis.

Balloon Valvuloplasty is procedure of choice for children and adults with asymptomatic PS with peak to peak gradient >30, and asymptomatic adult or children with peak to peak gradient >40 mm Hg at catheterization.

In patients with a coexisting hypoplastic pulmonary annulus, fixed subvalvar pulmonic stenosis, supravalvar pulmonic stenosis, or associated severe pulmonic regurgitation, valve replacement may be preferred.

**PULMONARY REGURGITATION**

Trivial or mild PR is detected by Doppler in most normal individuals. In adults pathological PR is most often is consequence of prior intervention for congenital heart disease.
Pathological regurgitation is distinguished from normal by wider jet and longer duration of flow. Rare causes include rheumatic heart disease, carcinoid heart disease, trauma and endocarditis.

The most common indications for intervention for pulmonic regurgitation in adults occur in patients with previous surgery for tetralogy of Fallot or pulmonic valve stenosis.

Pulmonic valve replacement for severe pulmonic regurgitation should be strongly considered in symptomatic patients, patients with progressive RA, RV dilatation or RV dysfunction and those undergoing other valve repair/replacement.\textsuperscript{42,43}

Bioprostheses are now the preferred prosthetic valve for pulmonic valve replacement.

Percutaneous pulmonic valve replacement is available and is commonly performed for patients with mixed pulmonic valve disease in Europe.

Another alternative is the valved bovine jugular vein conduit for right ventricular outflow tract reconstruction in children.\textsuperscript{44}

\textit{Percutaneous pulmonary valve replacement}

\textit{Prevention of Endocarditis in patients with valvular heart disease:}

According to the 2007 AHA guidelines on endocarditis prevention, antibiotic prophylaxis before dental work or other invasive procedures is no longer recommended in patients with rheumatic, degenerative or other forms of native valve disease. Antibiotic prophylaxis is only recommended in patients who have a previous history of endocarditis.\textsuperscript{45}

\textit{Indications for coronary angiography in patients with valvular heart disease:}

In patients with history of coronary artery disease, suspected myocardial ischemia, LV systolic dysfunction, in men over age of 40 and postmenopausal women and when CAD is suspected to be cause of MR. (ischemic MR)\textsuperscript{46} should undergo coronary angiogram prior to surgery.