SNS COLLEGE OF ALLIED HEALTH SCIENCES

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DEPARTMENT OF CARDIAC TECHNOLOGY -II YEAR

PAPER -III ECHOCARDIOGRAPHY

UNIT III : VALVULAR HEART DISEASES - PR

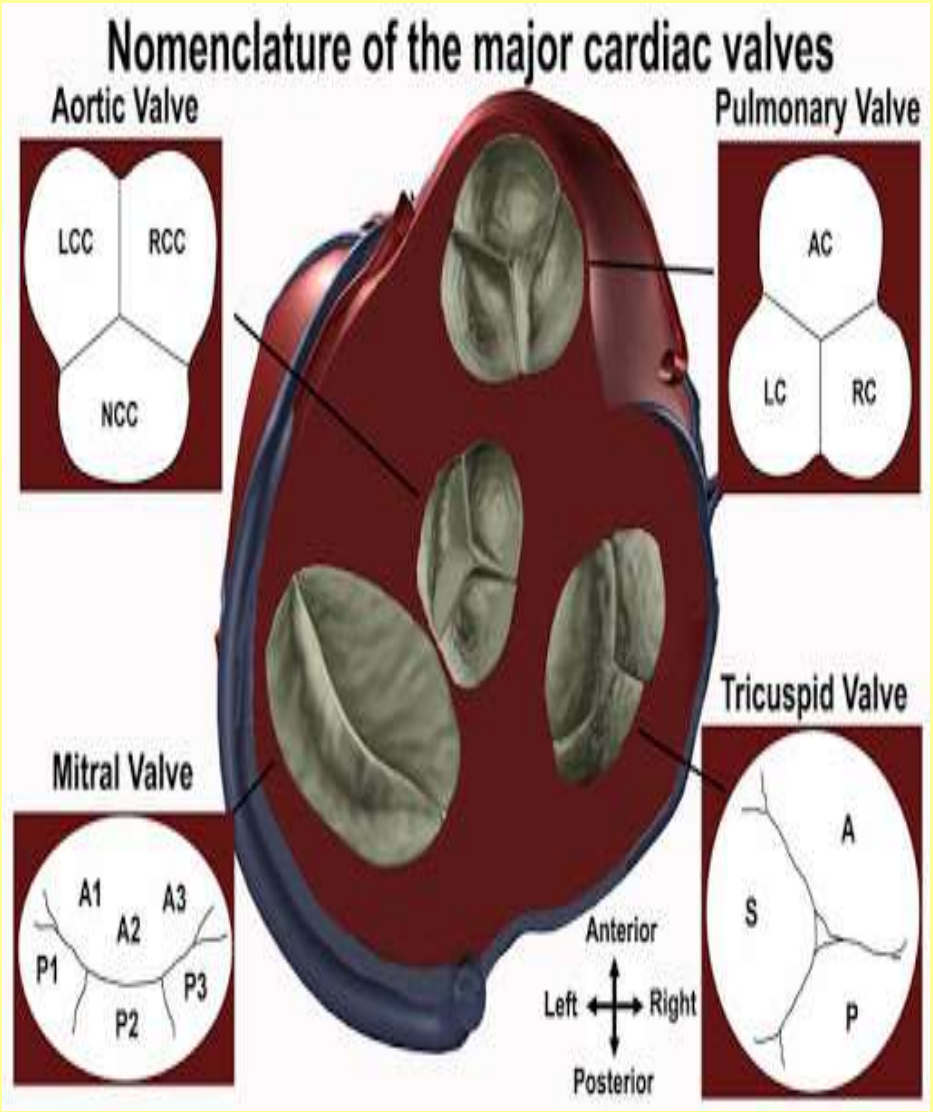
ECHOCARDIOGRAPHIC EVALUATION OF PR

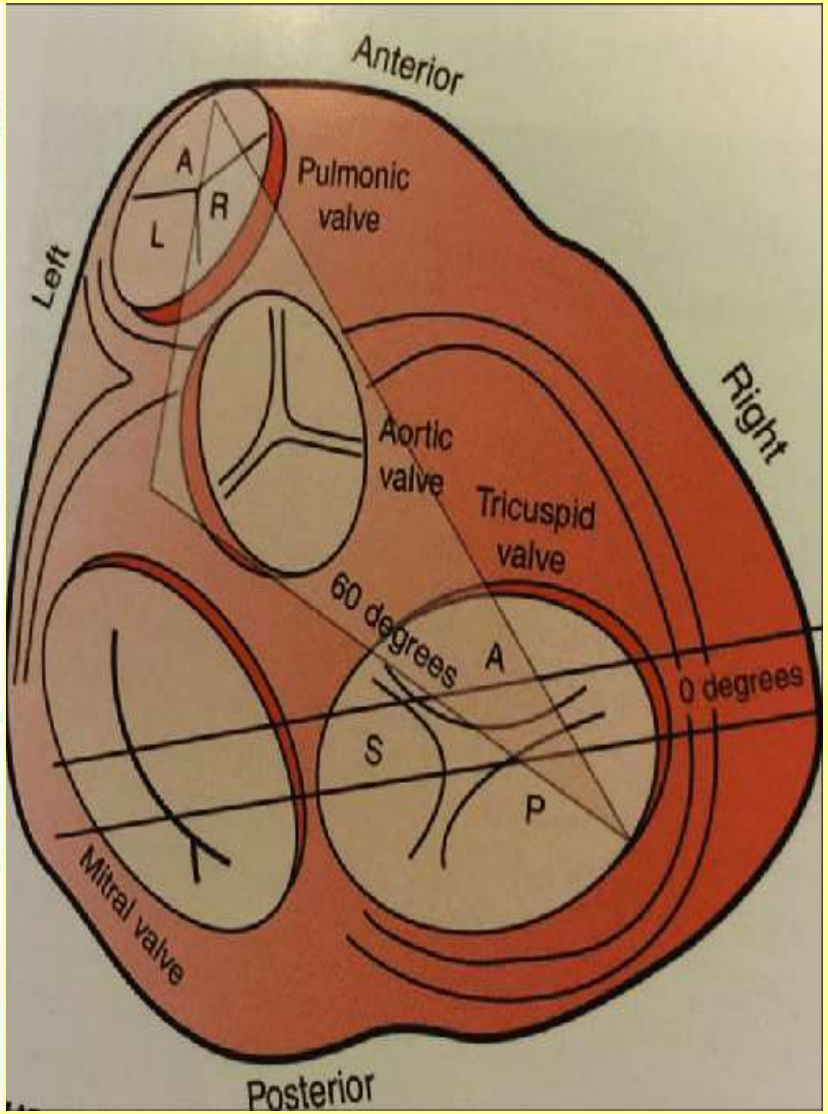
PULMONARY REGURGITATION

- Trace to mild PR, similar to TR, is a common finding and reported to occur in almost 75% of the population and is of little hemodynamic significance.
- The primary goal of imaging is to identify and assess abnormal degrees of PR, its etiology, and effect on cardiac structure and function.

A. Anatomy and General Imaging Considerations

- The PV is a semilunar valve with three cusps, located anterior and superior to the aortic valve. The PV cusps are thinner than those of the aortic valve.
- In the normal heart, the PA arises from a muscular infundibulum and therefore lacks fibrous continuity with the TV.
- The plane of the PV is orthogonal to that of the aortic valve.
- In addition to visualizing the valvular anatomy, the aims of imaging should include inspection of the RVOT, pulmonary annulus, main PA and proximal branches.
- The annulus and main PA may be dilated in patients with pulmonary hypertension and connective tissue disorders and in some patients with congenital heart disease.


Nomenclature of the major cardiac valves
Aortic Valve
LCC
RCC
NCC
Pulmonary Valve
AC
LC
RC
Tricuspid Valve
A
S
P
Mitral Valve
A1
A2
A3
P1
P2
P3
Anterior
Left
Right
Posterior


Anterior
A
R
L
Pulmonic valve
Left
Right
Aortic valve
Tricuspid valve
60 degrees
A
0 degrees
S
P
Mitral valve
Posterior

B. Etiology and Pathology

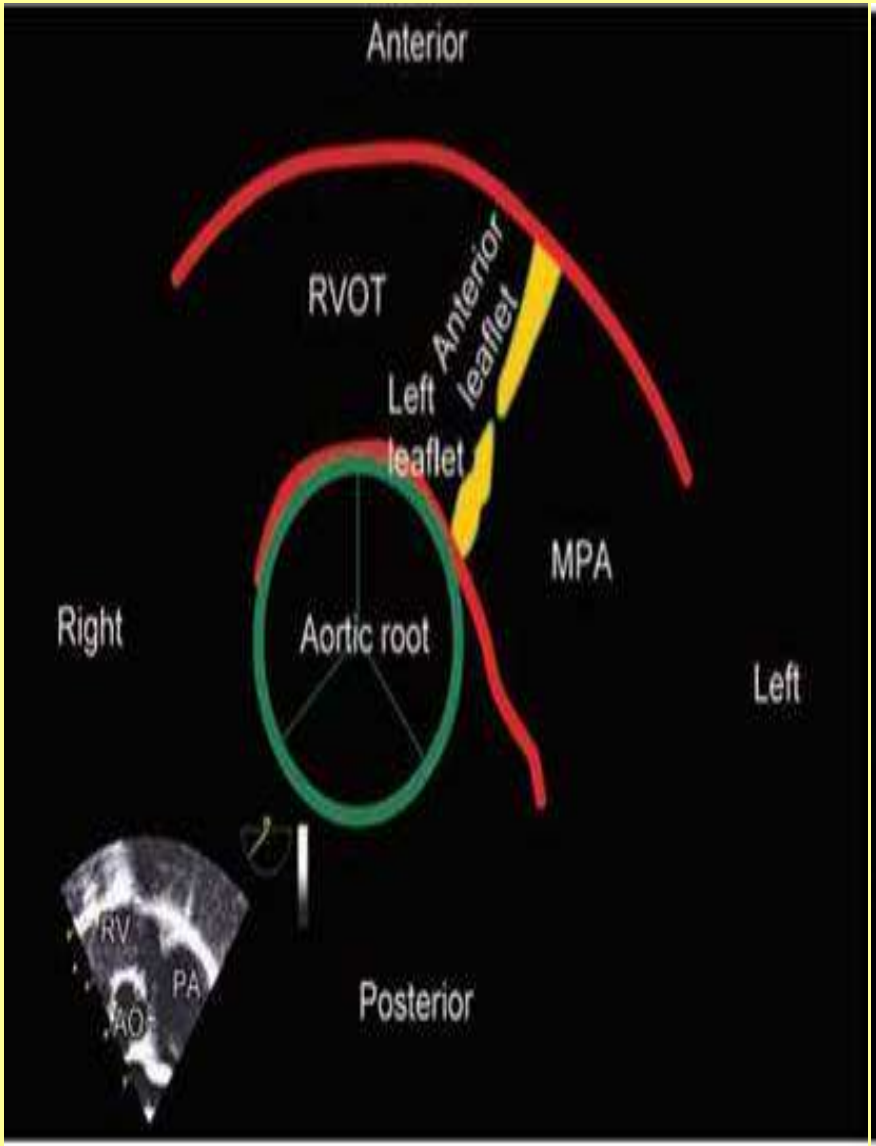
- Primary PR due to abnormal PV leaflets is more common in congenital heart disease and after balloon valvuloplasty for pulmonic stenosis than acquired valve disease.
- Significant acquired PR is rare, occurring in <1% of patients, and is present in adults with pathologies such as rheumatic heart disease, endocarditis, carcinoid valve disease, or pergolide-induced disease.
- Rarely blunt chest trauma can lead to leaflet disruption and prolapse.
- Secondary PR is most common in patients with elevated PA pressure, although the volume of regurgitation is usually small.
- By definition, the PV leaflets are normal with secondary PR.

C. Right Ventricular Remodeling

- Significant primary PR leads to an enlargement of the RV with preserved RV function and a volume overload pattern of the septum. Chronic severe PR may lead to RV dysfunction.
- However, RV dilation by itself is not a specific sign of significant PR since it can result from a number of conditions, so it is important to correlate RV dilation with the severity of PR by Doppler.
- In secondary PR, RV dilation and function as well as septal motion relate more to the underlying disease state (e.g., pulmonary hypertension severity) than to the degree of PR, which is usually at most moderate.

D. Echocardiographic Evaluation of PR Severity

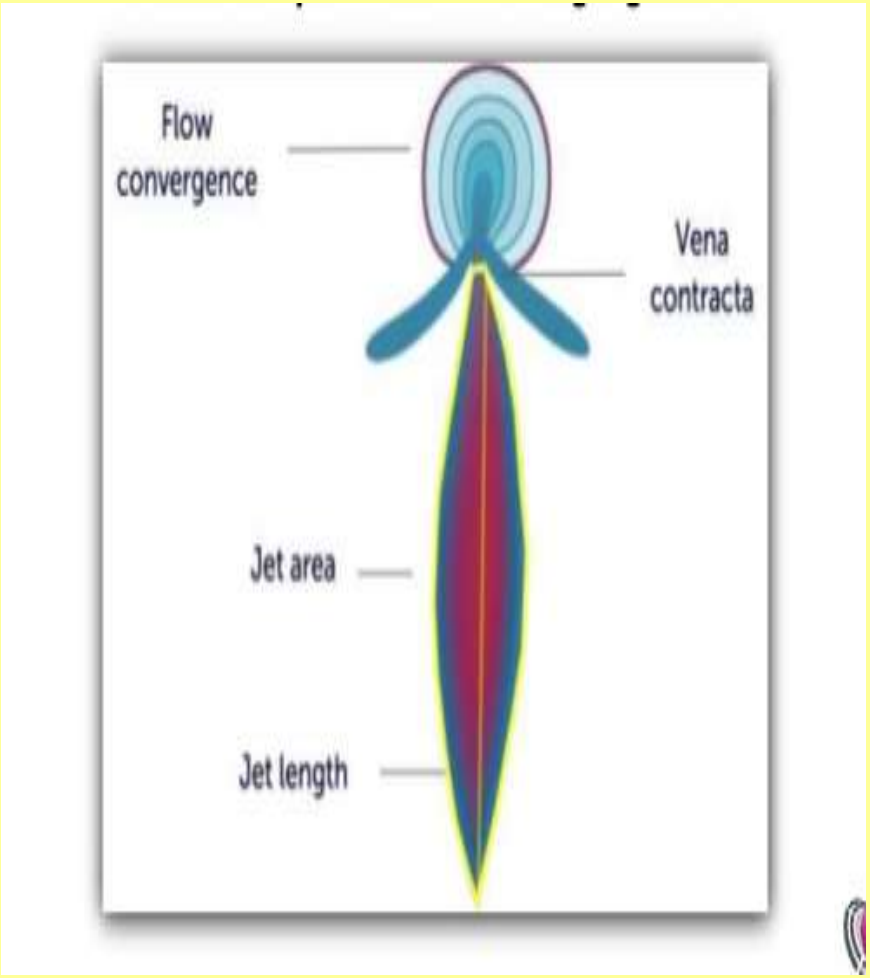
- The minor degrees of PR are common and have no clinical impact, and the low incidence of clinically significant PR in the adult.
- Most of the concepts for quantifying AR are applied to PR.


Anterior
RVOT
Anterior leaflet
Left leaflet
MPA
Right
Aortic root
Left
RV
PA
AO
Posterior


IVC
RVOT
RA
AO
MPA
LA
RPA

1. Color Flow Doppler

- Color Doppler assessment of PR severity includes
- proximal jet width
- color jet area
- Jet length.



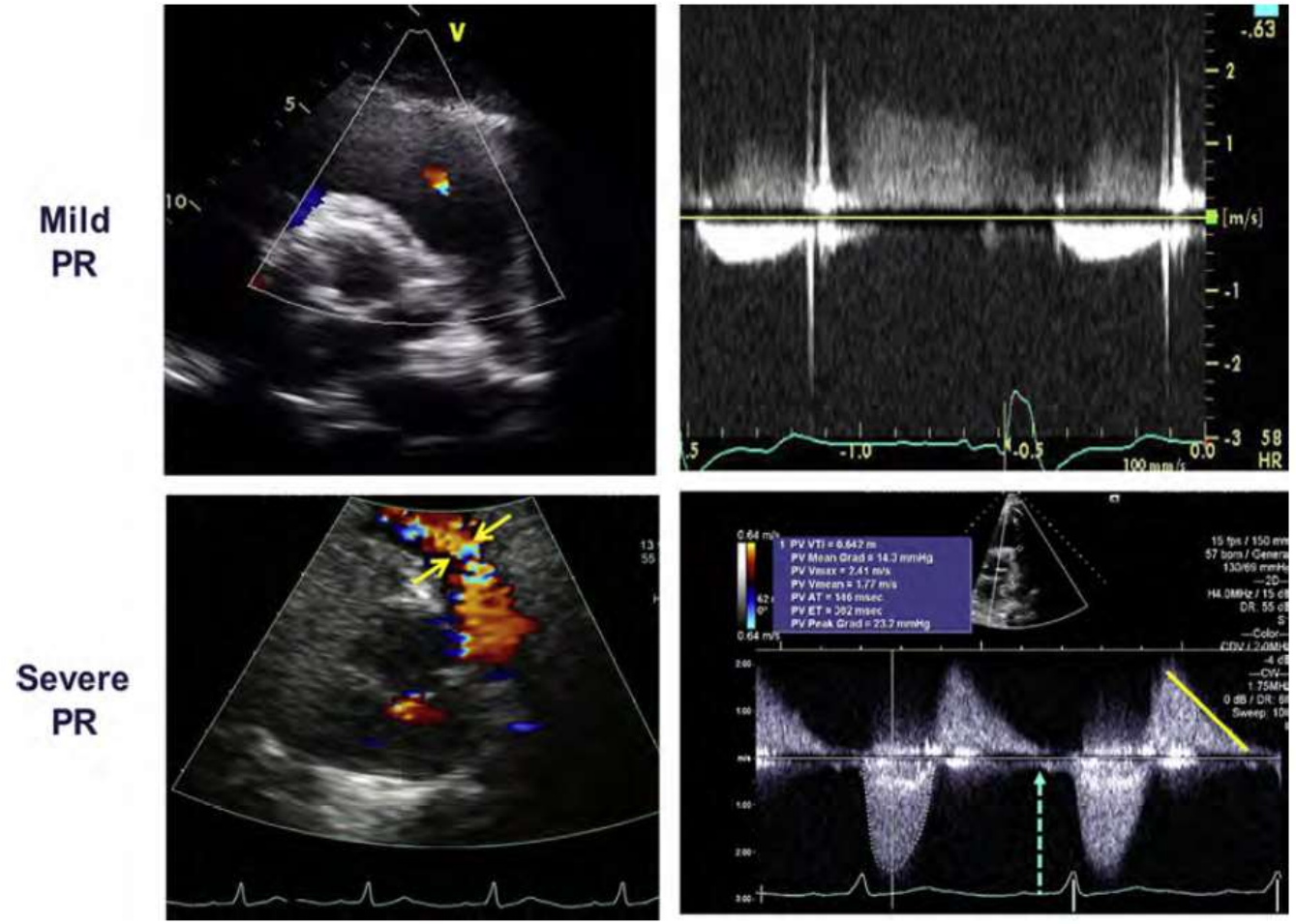


Figure 32 Examples of mild and severe PR depicting the difference in color jet, jet height (*between arrows*), and spectral density and deceleration of the PR jet by CWD. In severe PR, there is frequently early termination of the diastolic regurgitant flow (*green arrow*) with early equalization of RV and PA diastolic pressures.

1. Color Flow Doppler

- A jet length of <10 mm is considered to represent insignificant PR, particularly if narrow at the origin.
- The jet area has been related to various degrees of PR at angiography; however, significant overlap is seen, and it can be difficult to measure reproducibly.
- The proximal jet width (VC) is probably the most widely used semiqualitative color Doppler method.
- The VCW of the PR is commonly expressed as a ratio relative to the PV annulus diameter.
- It is important to note that in severe PR with normal PA pressures (e.g., primary PR), the color jet can be difficult to detect as the PR jet velocities are low, laminar, and brief in duration due to rapid equilibration of pressures across the PV.
- In secondary PR with pulmonary hypertension, the jet is aliased, of high velocity, and usually holodiastolic.

2. Pulsed and Continuous Wave Doppler

- The density of the CW signal provides a qualitative measure of regurgitation.
- The CW pattern seen in mild PR shows a soft or faint signal with slow deceleration.
- In contrast, severe PR has a dense jet with rapid deceleration of the velocity due to the rapid equilibration of the diastolic pressure gradient between the PA and RV .
- This ‘‘to-and fro’’ flow across the PV shows a characteristic ‘‘sine wave’’ shape.
- It is important to note that rapid deceleration by itself is not specific for severe PR and can be seen in conditions with decreased RV compliance.
- Judging the severity of PR in these situations will depend on color Doppler characteristics of the PR jet and comparative flow considerations.

2. Pulsed and Continuous Wave Doppler

- Few indices have been proposed to quantitate the deceleration of the PR velocity and its premature diastolic termination.
- A pressure half-time of <100 msec (or deceleration time of < 260 msec) has been shown to be consistent with severe PR.
- A PR index has also been suggested, calculated as the ratio of PR duration by CWD to total diastolic time .
- An additional sign of severe PR by pulsed Doppler is the presence of reverse flow in the PA.
- The presence of diastolic flow reversal in the branch pulmonary arteries had a sensitivity and specificity of 87% for severe PR.
- It is important to visualize and sample flow in the branch pulmonary arteries and not just in the main PA.

PR INDEX

PR severity (CW Doppler)

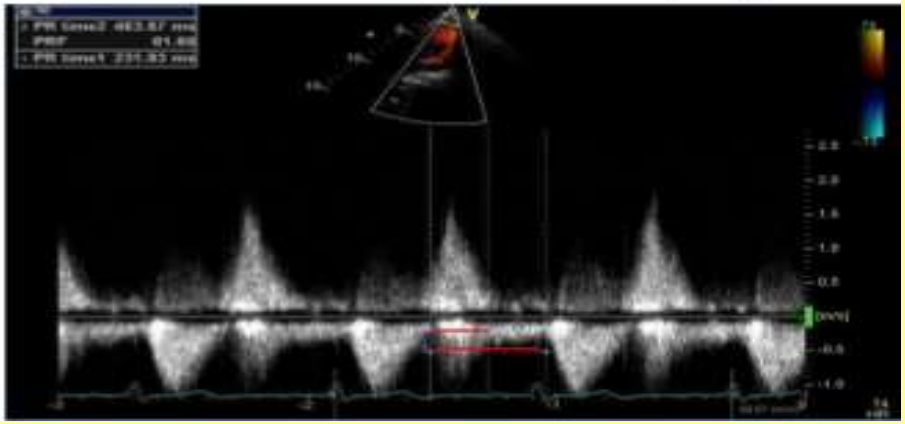
- **PR duration**: from the onset in early diastole to the end of the PR Doppler signal
- **Total diastolic time**: measured from the end of forward pul flow (coinciding with the onset of the retrograde PR flow) to the beginning of the next forward pulmonary flow curve

- The ratio btw duration of PR and total diastolic time = **PR index** (Pri)

  - Mild : through diastole
  - Moderate: late diastole
  - Severe: mid-diastole or earlier

<0.77 : significant PR

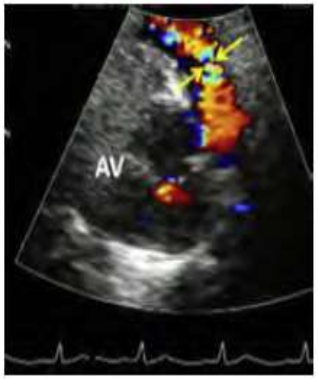
Am Heart J 2004;147:165–172

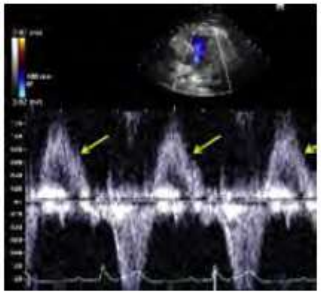
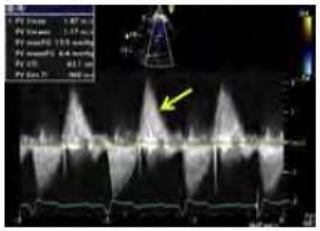
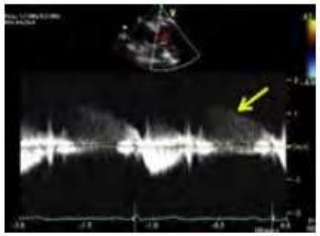


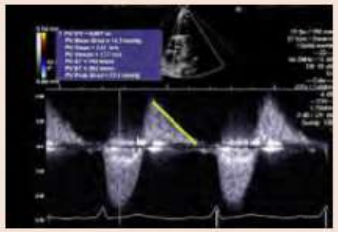
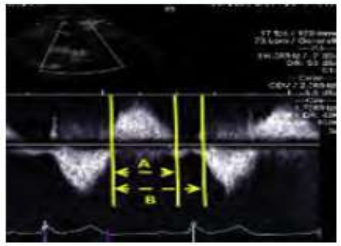
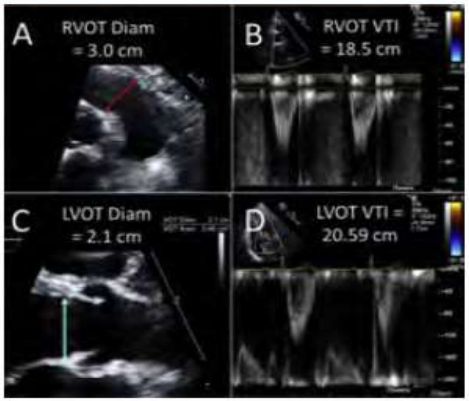
3. Quantitative Doppler

- Quantitative pulsed Doppler methods can be used to measure PR RVol and fraction.
- The RVOT, however, is probably the most difficult site to measure SV because of its poor visualization and the changing size of the RVOT during the cardiac cycle.
- The RVOT is measured during early ejection (two to three frames after the R wave on the electrocardiogram) just below the PV in the parasternal short-axis view.
- Although not validated for quantitation of PR, flows in the RVOT can be compared to other sites to derive RVol and fraction.

Table 15 Doppler echocardiography in evaluating severity of PR

Modality	Optimization	Example	Advantages	Pitfalls
Color flow Doppler 2D				
VC	• Parasternal short-axis or subcostal views • Zoomed view • Should visualize proximal flow convergence, distal jet, and the "narrow" neck in a single view • Measured in diastole immediately below PV		• Surrogate for effective regurgitant orifice size • Independent of flow rate and driving pressure for a fixed orifice • Less dependent on technical factors	• Not usable with multiple jets • The direction of the jet (in relation to the insonation beam) will influence the appearance of the jet • Cutoffs for various grades of PR not validated. • Not easy to perform
VCW/PV annular diameter ratio	• Parasternal short-axis view • Zoomed view • Optimize visualization of proximal PA		• Simple sensitive screen for PR • Rapid qualitative assessment	• Underestimates PR in eccentric jets • Overestimates PR in central jets • PR jet may expand unpredictably below the orifice

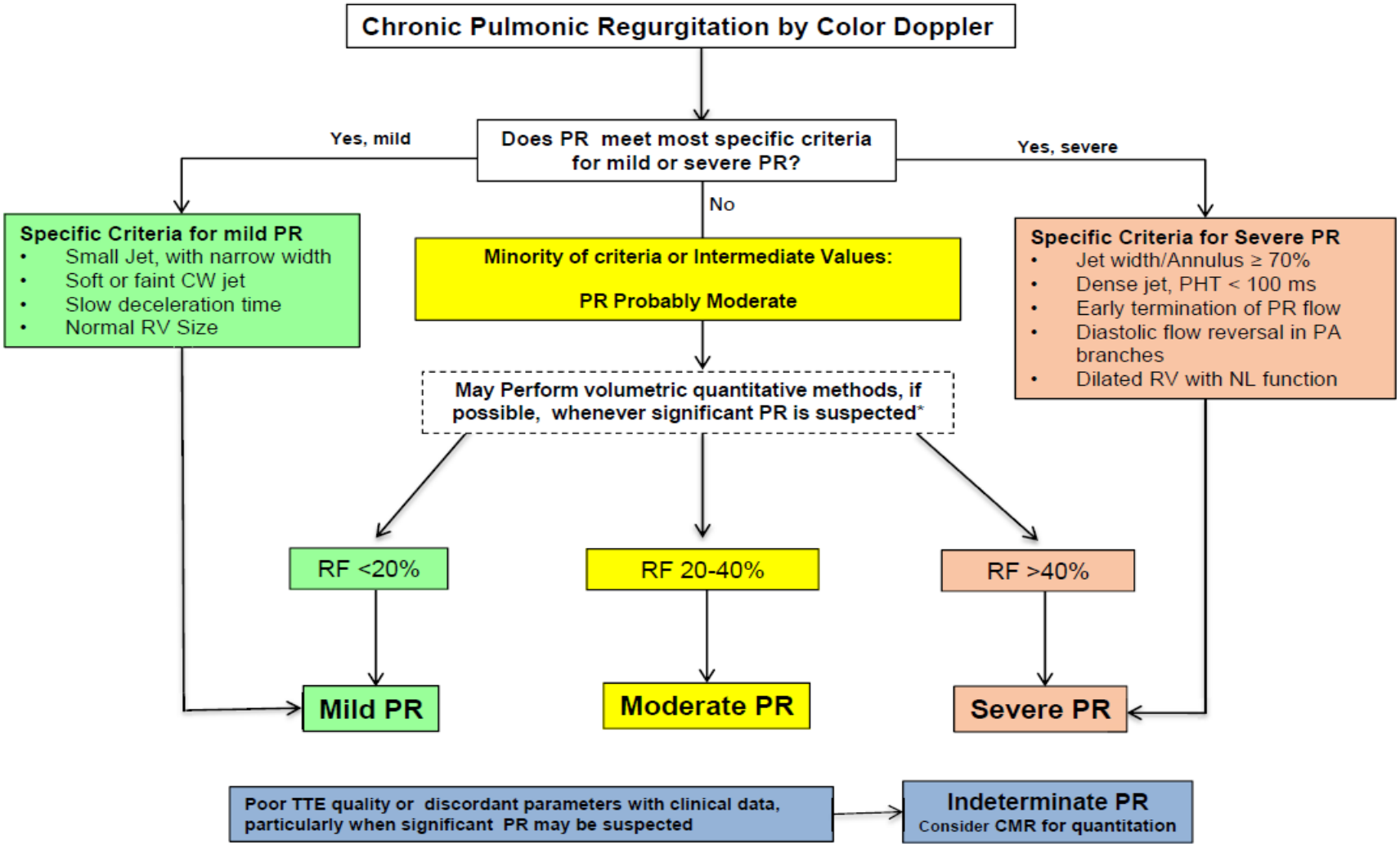
Pulsed wave Doppler: flow reversal in the branch PA	• Align insonation beam with the flow in the RPA and LPA • Obtain pulsed wave Doppler from both branch PAs		• Simple supportive sign of severe PR	• Depends on compliance of the PA • Brief velocity reversal is normal
CWD				
Density of regurgitant jet	• Align insonation beam with the flow • PSAX view or subcostal views	Severe PR with dense jet  Mild PR 	• Simple • Density is proportional to the number of red blood cells reflecting the signal • Faint or incomplete jet is compatible with mild PR	• Qualitative • Perfectly central jets may appear denser than eccentric jets of higher severity • Overlap between moderate and severe PR

Modality	Optimization	Example	Advantages	Pitfalls
Jet deceleration rate (pressure half-time)	• Align insonation beam with the flow • PSAX view or subcostal views		• Simple • Specific sign of pressure equalization • Values < 100 msec consistent with severe PR	• Poor alignment of Doppler beam may result in eccentric jets providing low PHT • Affected by RV and PA pressure difference, e.g., RV diastolic dysfunction.
The PR index (A/B)	• Align insonation beam with the flow • PSAX view or subcostal views • Ensure complete forward and regurgitant flow spectral Doppler		• Uses combination of PR duration and duration of diastole • Accounts for pressure differences between PA and RV	• Affected by RV diastolic dysfunction and RV diastolic pressures.
Quantitative Doppler: RVol and fraction				
$RVol = SV_{RVOT} - SV_{LVOT}$ $RF = RVol/SV_{RVOT}$	• Pulmonic annulus from PSAX view, measured during early ejection just below PV • Pulsed Doppler in RVOT from PSAX • Aortic annulus measured in early systole from PLA • Pulsed Doppler in LVOT from apical window.		• Quantitative, valid with multiple jets and eccentric jets. Provides lesion severity (RF) and volume overload (RVol); EROA not validated	• Difficulties measuring RVOT diameter • In case of AR, would need to use the mitral annulus site. • Experience is scant

GRADING OF PR

Table 16 Echocardiographic and Doppler parameters useful in grading PR severity

Parameter	Mild	Moderate	Severe
Pulmonic valve	Normal	Normal or abnormal	Abnormal and may not be visible
RV size	Normal*	Normal or dilated	Dilated†
Jet size, color Doppler‡	Thin (usually <10 mm in length) with a narrow origin	Intermediate	Broad origin; variable depth of penetration
Ratio of PR jet width/pulmonary annulus			>0.7§
Jet density and contour (CW)	Soft	Dense	Dense; early termination of diastolic flow
Deceleration time of the PR spectral Doppler signal			Short, <260 msec
Pressure half-time of PR jet			<100 msec‖
PR index¶		<0.77	<0.77
Diastolic flow reversal in the main or branch PAs (PW)			Prominent
Pulmonic systolic flow (VTI) compared to systemic flow (LVOT VTI) by PW#	Slightly increased	Intermediate	Greatly increased
RF**	<20%	20%-40%	>40%


Chronic Pulmonic Regurgitation by Color Doppler
Does PR meet most specific criteria for mild or severe PR?
Yes, mild
Yes, severe
No
Specific Criteria for mild PR
• Small Jet, with narrow width
• Soft or faint CW jet
• Slow deceleration time
• Normal RV Size
Minority of criteria or Intermediate Values:
PR Probably Moderate
Specific Criteria for Severe PR
• Jet width/Annulus ≥ 70%
• Dense jet, PHT < 100 ms
• Early termination of PR flow
• Diastolic flow reversal in PA branches
• Dilated RV with NL function
May Perform volumetric quantitative methods, if possible, whenever significant PR is suspected*
RF <20%
RF 20-40%
RF >40%
Mild PR
Moderate PR
Severe PR
Poor TTE quality or discordant parameters with clinical data, particularly when significant PR may be suspected
Indeterminate PR
Consider CMR for quantitation