Tricuspid Regurgitation(TR)
Pulmonary Regurgitation(PR)

European Journal of Echocardiography 2010;11: 223-244 & 307-332

Tricuspid Regurgitation

European Journal of Echocardiography 2010;11: 307-332

2D and 3D recordings of TR

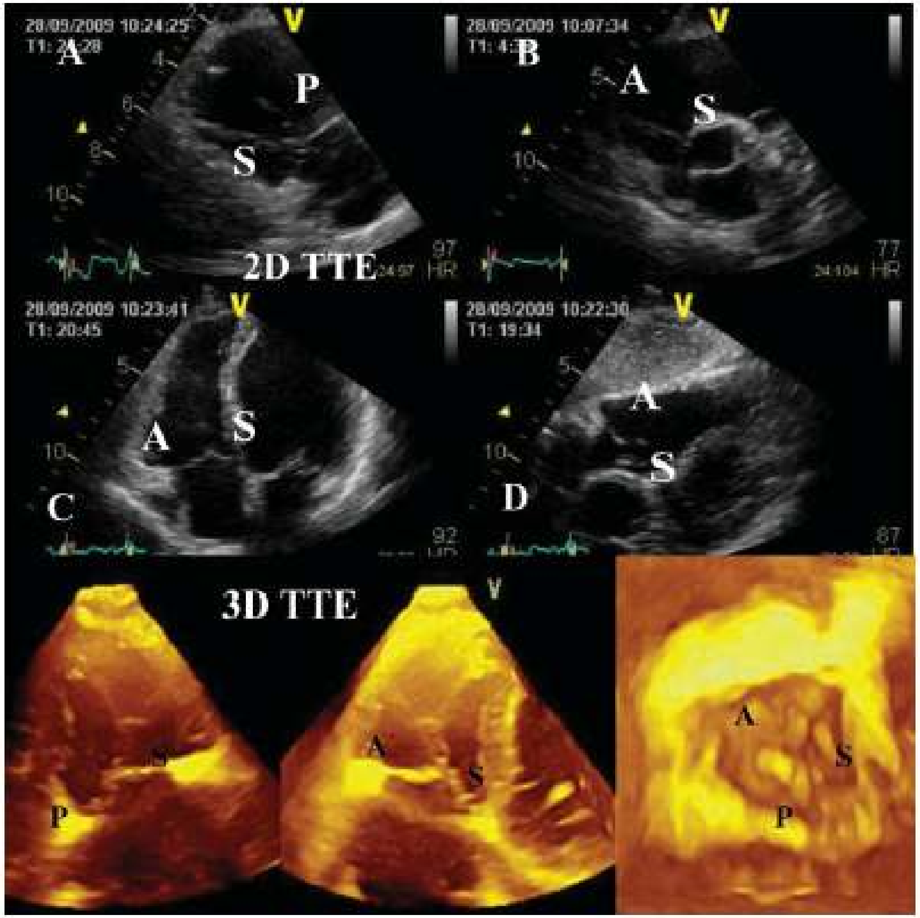


Figure 26 2D and 3D echo recordings of the tricuspid valve. (*A*) Parasternal long-axis view; (*B*) parasternal short-axis view at the level of the aortic valve; (*C*) apical four-chamber view; (*D*) sub-costal view. A, anterior leaflet; S, septal leaflet; P, posterior leaflet.

Etiology

- Physiological TR
- Pathologic TR

Physiologic TR

- Normal valve leaflet
- No dilatation of RV
- Small region adjacent to valve closure (< 1 cm) with a thin, central jet
- Peak systolic velocity : 1.7-2.3 m/s

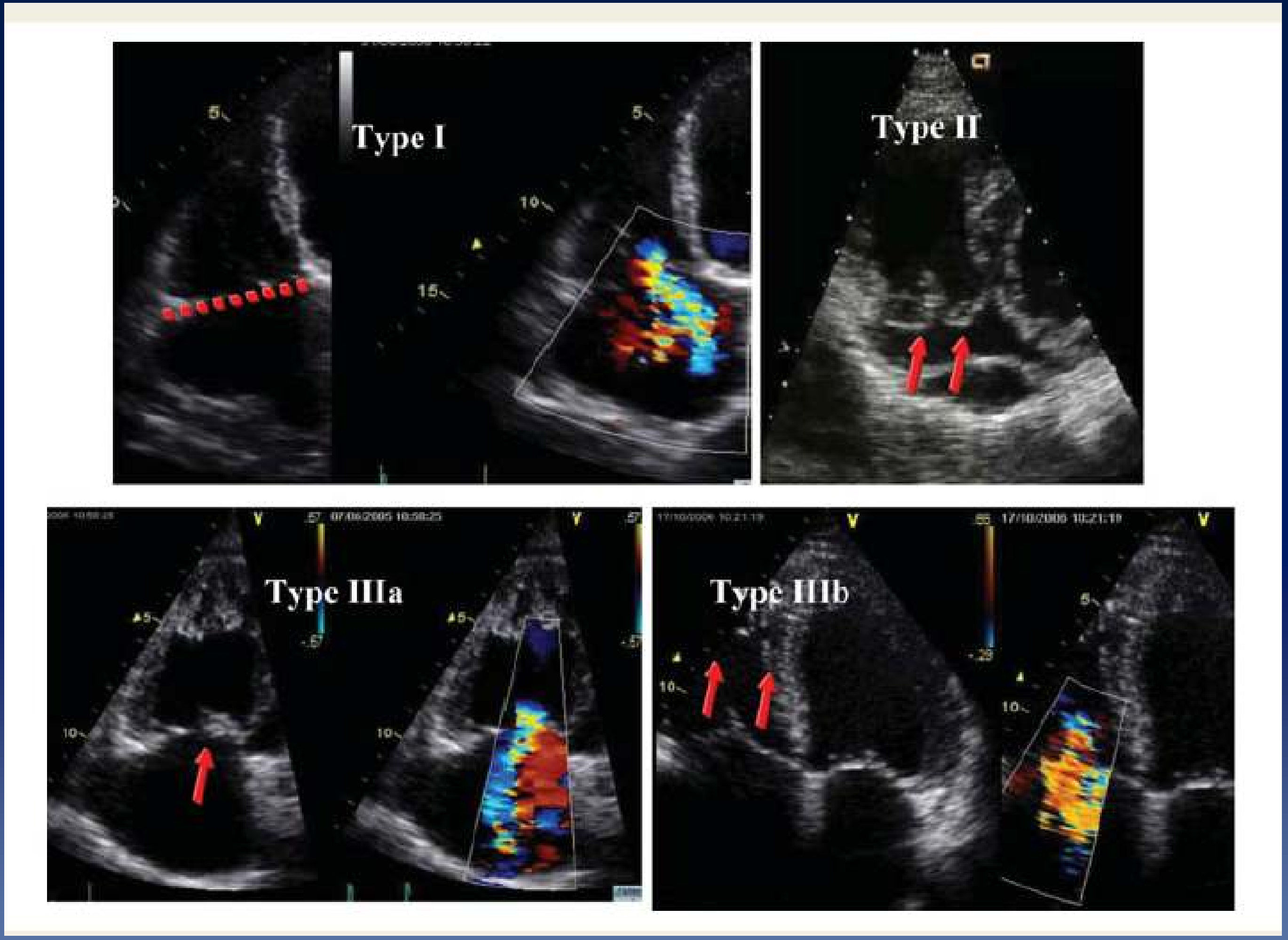
Pathologic TR

- The most common cause of TR
  - Not a primary tricuspid valve disease (organic TR)
  - An impaired valve coaptation (secondary or functional TR) caused by the dilatation of the RV and/or the annulus
    - Left-sided valve heart diseases
    - Pulmonary hypertension
    - Congenital heart defects
    - cardiomyopathy

Carpentier classification of TR

- Type I : normal leaflet motion
  - Annulur dilatation
  - Leaflet perforation: infective endocarditis
- Type II: excessive leaflet motion
  - Prolapse of one or more leaflets : tricuspid valve prolapse
- Type III: restrictive leaflet motion
  - Rheumatic disease
  - Significant calcification
  - Toxic valvulopathy
  - Functional TR

Capentier Classification of TR



Assessment of severity of TR

- Color flow Doppler
  - Color flow imaging
  - Vena contracta width
  - The flow convergence method
- Pulse Doppler
- Continuous-wave Doppler

Color flow imaging

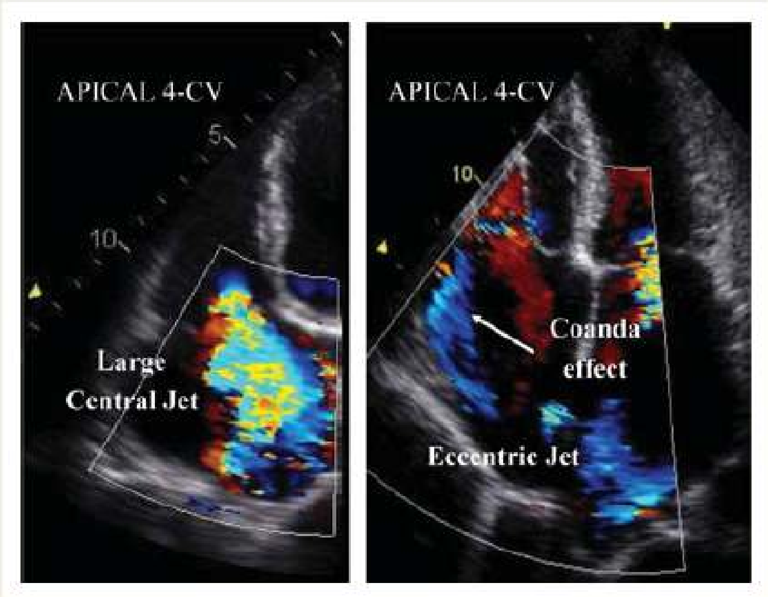
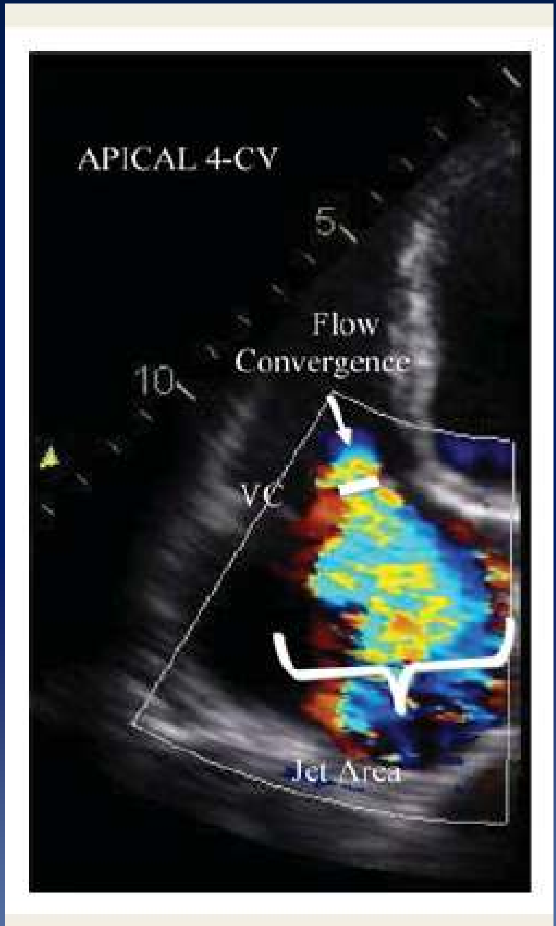


Figure 28 Visual assessment of tricuspid regurgitant jet using colour-flow imaging. (*A*) Large central jet; (*B*) eccentric jet with a clear Coanda effect. CV, four-chamber view.

- Not recommended to *quantify* the severity of TR.
- *Only used for diagnosing TR.*

Vena Contracta width



- Typically imaged in the apical 4-chmaber view
- *VC width ≥ 7mm : severe TR*
- VC width < 6mm: strong argument for mild or moderate TR.

The flow convergence method

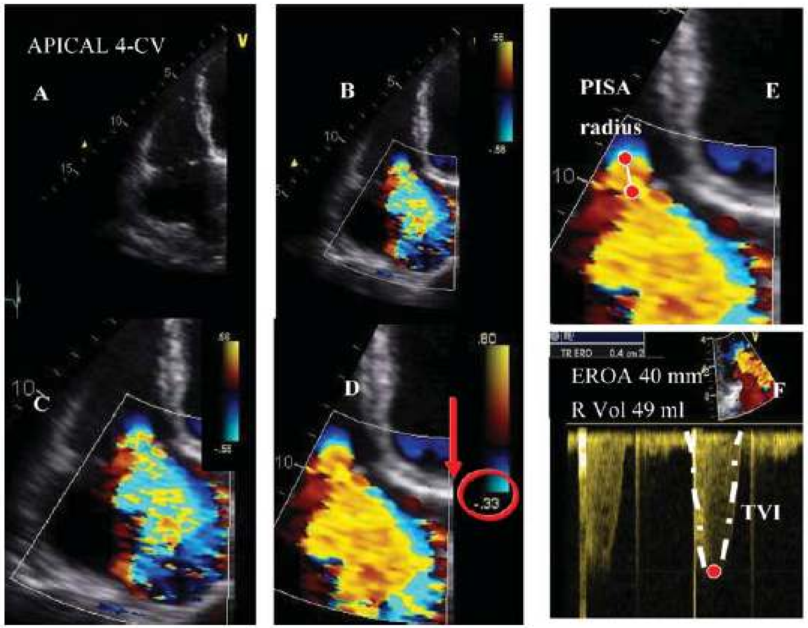


Figure 30 Quantitative assessment of TR severity using the proximal isovelocity surface area (PISA) method. Stepwise analysis of mitral regurgitation: (*A*) Apical four-chamber view (CV); (*B*) colour-flow display; (*C*) zoom of the selected zone; (*D*) downward shift of zero baseline to obtain an hemispheric PISA; (*E*) measure of the PISA radius using the first aliasing; (*F*) continuous wave Doppler of tricuspid regurgitation jet allowing calculation the effective regurgitant orifice area (EROA) and regurgitant volume (R Vol). TVI, time-velocity integral.

PISA (hemisphere) = $2\pi r^2$

Flow at PISA = PISA x $V_{aliasing}$

Flow at orifice = ERO x $V_{orifice}$

Flow at PISA = Flow at orifice

PISA x $V_{aliasing}$ = ERO x $V_{orifice}$

The flow convergence method

- Under Nyquist limit to ~15-40cm/s
  - PISA radius:
    - > 9mm : severe TR
    - < 5mm : mild TR
  - EROA $\geq$ 40 mm^2 : severe TR
  - R Vol > 45 ml : severe TR

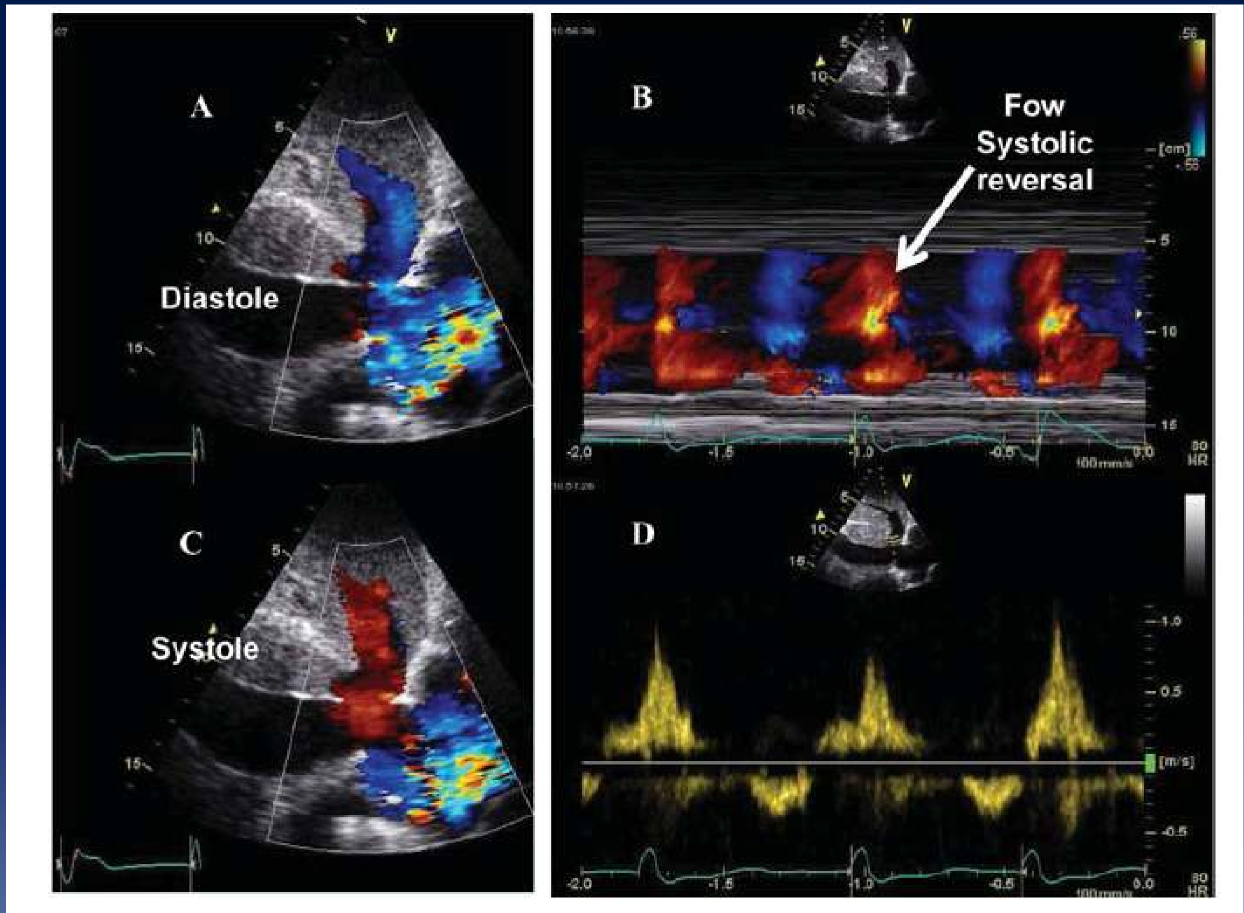
Limitation of the flow convergence method

- Underestimate the severity of TR by 30%
- Less accurate in eccentric TR
- The number of studies are still limited

Pulse Doppler

- Antegrade velocity of tricuspid inflow
  - In the absence of tricuspid stenosis
    - Peak E velocity > 1 m/s : severe TR
- Hepatic vein flow

Hepatic reversal flow



Continuous-wave Doppler

- The CW envelop of the TR jet can be a guide to TR severity

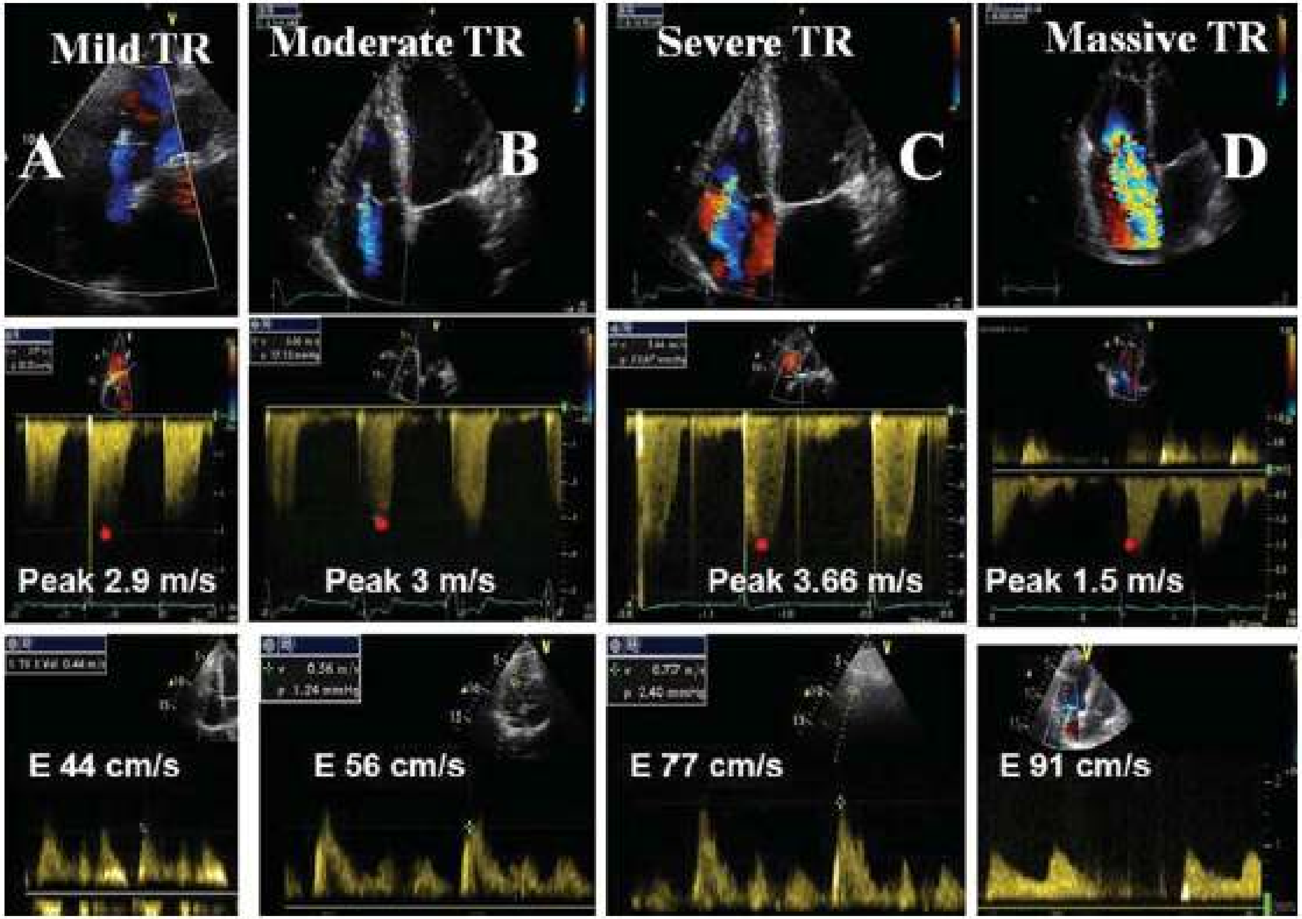


Figure 31 Four examples of various degrees of tricuspid regurgitation (TR), mild (*A*), moderate (*B*), severe (*C*), and massive (*D*) are provided. The regurgitant jet area (RJA) as well as the tricuspid *E* wave velocity increase with the severity of TR. In severe TR, the continuous wave Doppler signal of the regurgitant jet is truncated, triangular and intense. The peak velocity of TR (continuous wave Doppler) allows the estimation of pulmonary pressure except in case of massive TR, since the Bernouilli equation is not applicable.

Signs of severe TR

- RA and RV dilatation
- Pulsatile IVC and hepatic veins
- A dilated coronary sinus
- Systolic bowing of interatial septum toward LA
- Rapid anterior motion of IVS at the onset of systole : a qualitative sign of RV volume overload due to severe TR
  - Not specific

Table 5 Grading the severity of TR

Parameters	Mild	Moderate	Severe
Qualitative			
Tricuspid valve morphology	Normal/abnormal	Normal/abnormal	Abnormal/flail/large coaptation defect
Colour flow TR jet[a]	Small, central	Intermediate	Very large central jet or eccentric wall impinging jet
CW signal of TR jet	Faint/Parabolic	Dense/Parabolic	Dense/Triangular with early peaking (peak <2 m/s in massive TR)
Semi-quantitative			
VC width (mm)[a]	Not defined	<7	≥7
PISA radius (mm)[b]	≤5	6–9	>9
Hepatic vein flow[c]	Systolic dominance	Systolic blunting	Systolic flow reversal
Tricuspid inflow	Normal	Normal	E wave dominant (≥1 cm/s)[d]
Quantitative			
EROA (mm^2)	Not defined	Not defined	≥40
R Vol (mL)	Not defined	Not defined	≥45
+ RA/RV/IVC dimension[e]			

Pulmonary Regurgitaion

European Journal of Echocardiography 2010;11: 223-244

2D and 3D recordings of PV

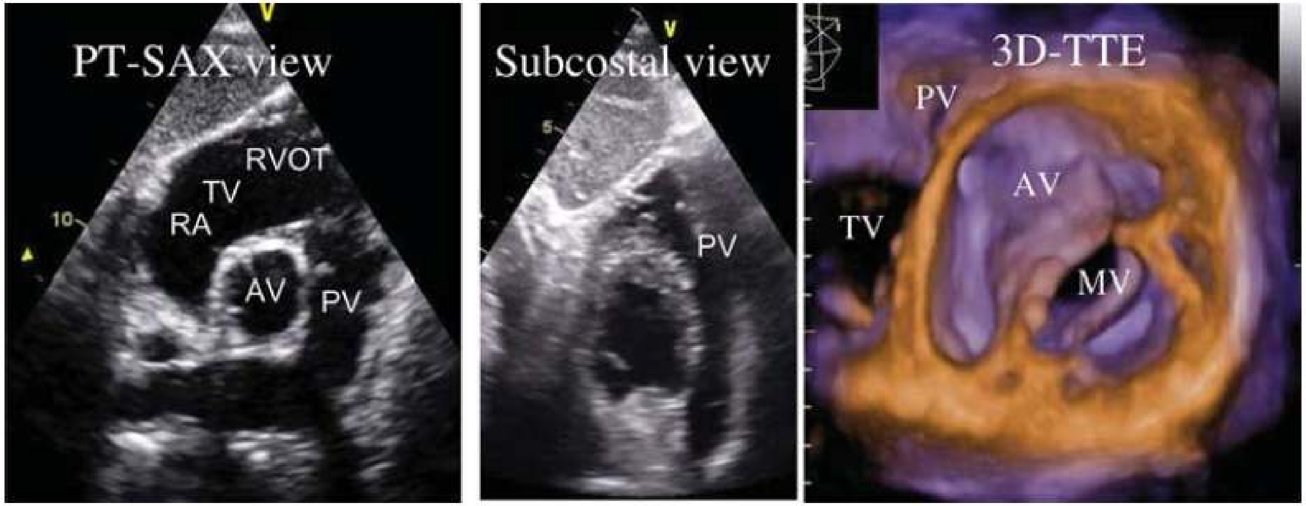


Figure 14 Two- and three-dimensional echo recordings of the pulmonic valve. PT-SAX, parasternal short-axis view.

Etiology of PR

- Congenital anomalies
  - Quadricuspid or bicuspid valves
- Hypoplasia
- Post-repair of tetralogy of Fallot
- Prolapse of the pulmonary valve
- Others
  - Infective endocarditis
  - Carcinoid syndrome
  - Rheumatic heart disease
  - Myxomatous change of valve

Assessment of PR severity

- Color Doppler flow
  - Color flow imaging
  - Vena contracta
  - The flow convergence method
- Pulse Doppler
- Continuous-wave Doppler

Color flow imaging

- Estimating the diameter of PR jet at its origin
  - In diastole
    - PR width/RVOT width > 65% → severe PR
  - High inter-observer variability

Vena contracta width

- Probably accurate
- Lack validate studies
- 3 D provide more quantitative assessment of PR

	Mild	Moderate	Severe
EROA (mm^2)	< 20	21-115	>115
R volume (ml)	< 15	15-115	> 115

Vena Contracta

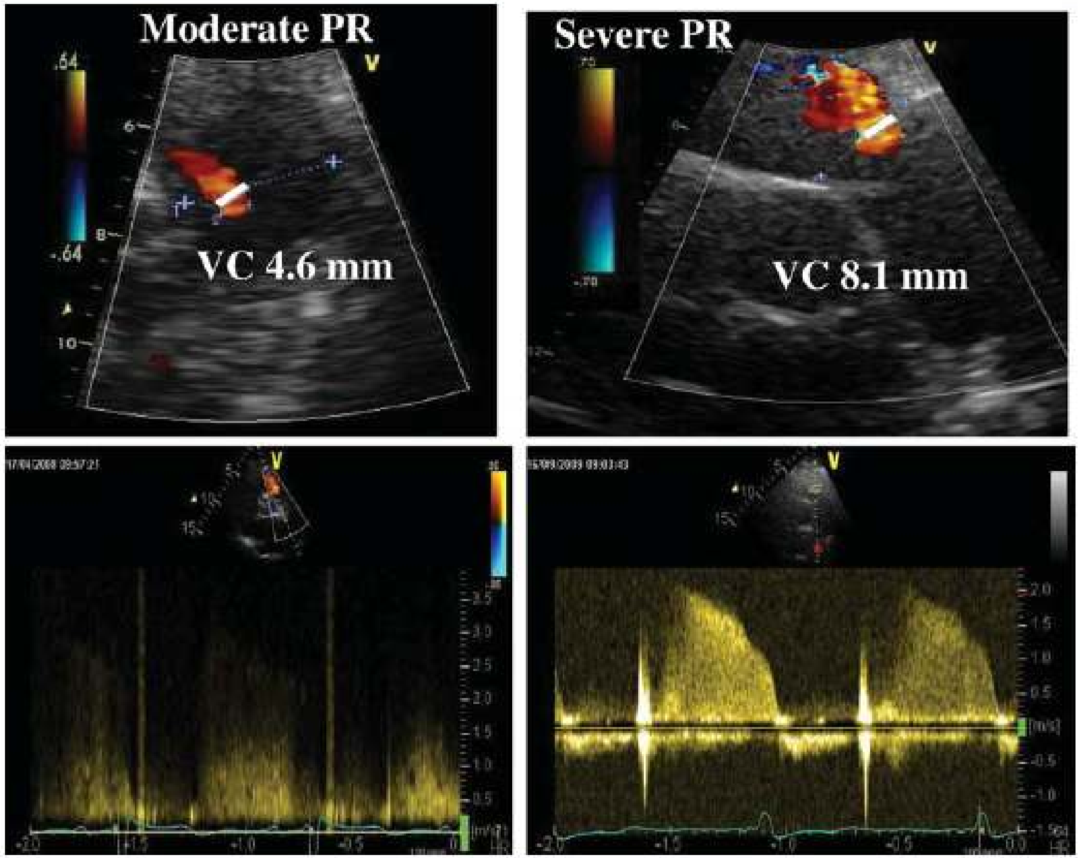


Figure 15 Assessment of pulmonary regurgitation (PR) severity by using colour flow imaging. (Top) Measurement of the vena contracta width in two patients with PR (left: moderate, right: severe). (Bottom) Continuous-wave Doppler recordings.

Vena Contracta

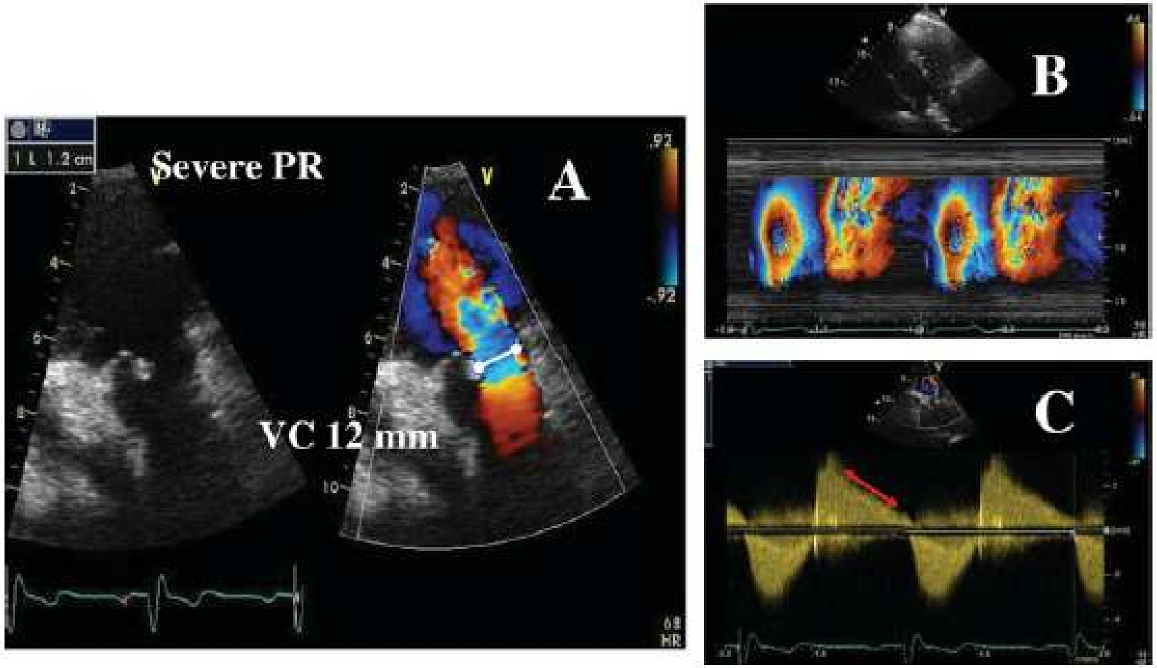


Figure 16 Example of a patient with a severe pulmonary regurgitation (PR). (*A*) Complete lack of valve coaptation (left) and measurement of the vena contracta width (VC) (right); (*B*) colour-coded M-mode depicting the time dependency of flow signal during the heart cycle; (*C*) continuous Doppler recording of PR showing a rapid flow deceleration during the diastole (red arrow) and increased systolic flow velocity (not related to concomitant pulmonary stenosis).

The flow convergence method

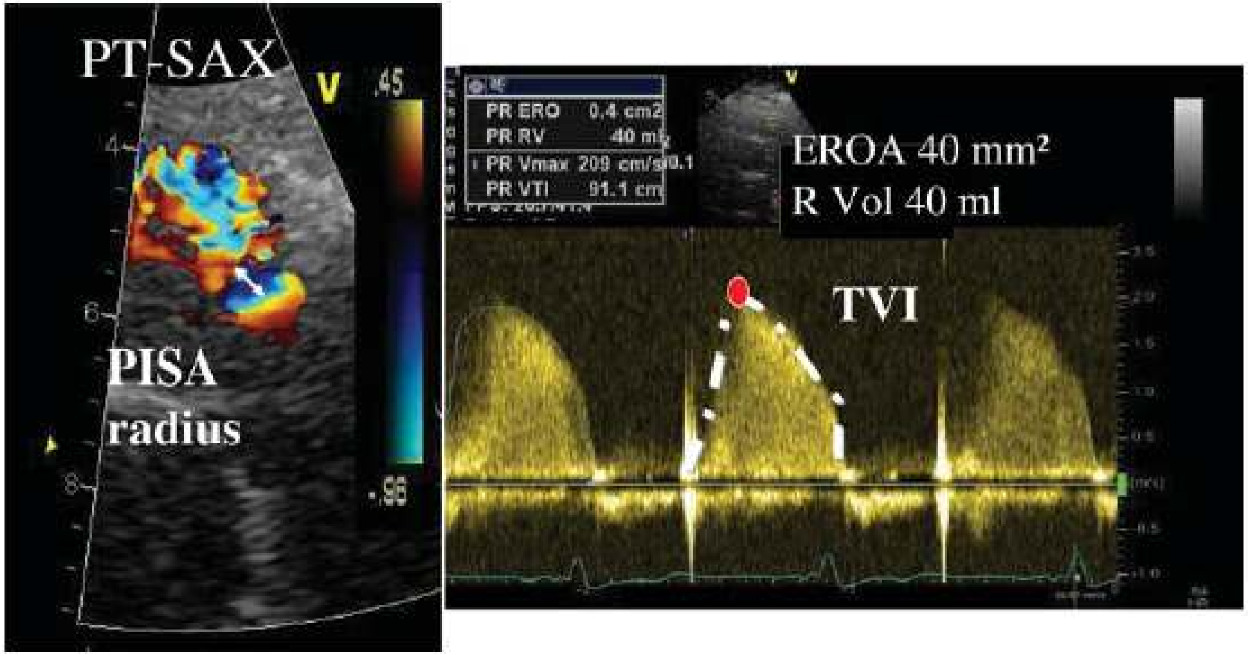


Figure 17 Assessment of pulmonary regurgitation by the proximal isovelocity surface area (PISA) method. PT-SAX, parasternal short-axis view; EROA, effective regurgitant orifice area; R Vol, regurgitant volume.

No studies have examined the clinical accuracy of this method by quantifying the severity of the PR.

Pulse Doppler

- Theoretically, PW Doppler assessment of the forward and reverse flows of the pulmonary annulus and the pulmonary artery can be used to calculate R vol and refurgitation fraction.
- Subject to error in measurement
- Not well validated.

Continuous-wave Doppler

- No clinically accepted method of quantifying PR using CW Doppler.
- The density of CW signal provides a qualitative measue of PR.

Consequences of PR

- Evaluation of the function and size of RV in the absence of pulmonary hypertension provides the indirect clues to the severity of PR.
  - Absence of RV dilatation : mild PR

Table 4 Grading the severity of PR

Parameters	Mild	Moderate	Severe
Qualitative			
Pulmonic valve morphology	Normal	Normal/ abnormal	Abnormal
Colour flow PR jet width[a]	Small, usually <10 mm in length with a narrow origin	Intermediate	Large, with a wide origin; may be brief in duration
CW signal of PR jet[b]	Faint/slow deceleration	Dense/variable	Dense/steep deceleration, early termination of diastolic flow
Pulmonic vs. Aortic flow by PW	Normal or slightly increased	Intermediate	Greatly increased
Semi-quantitative			
VC width (mm)	Not defined	Not defined	Not defined
Quantitative			
EROA (mm^2)	Not defined	Not defined	Not defined
R Vol (mL)	Not defined	Not defined	Not defined
+RV size[c]			