



De rechter ventrikel bij kleplijden

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Disclosure belangen spreker

(Potentiële) belangenverstrengeling Geen

Voor bijeenkomst mogelijk relevante relaties met bedrijven -

Sponsoring of onderzoeksgeld -

Honorarium of andere (financiële) vergoeding -

Aandeelhouder -

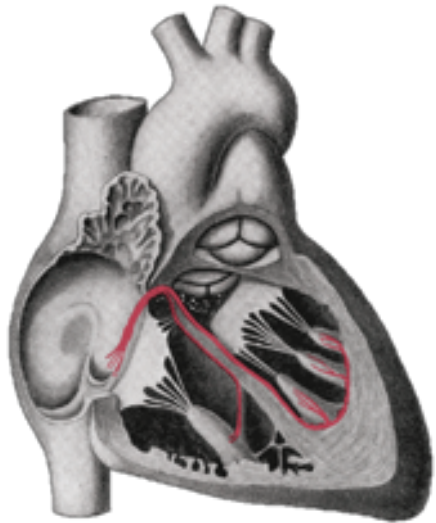
Andere relatie, namelijk ... -



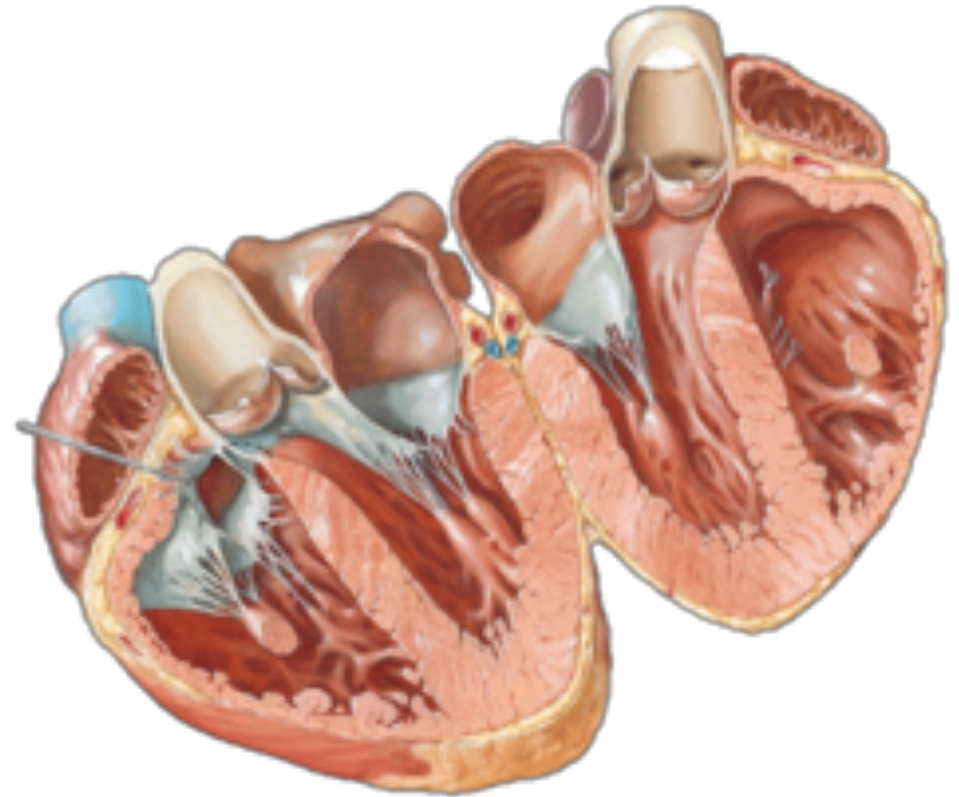
De linker en rechterkamer lijken op elkaar, maar zijn *different animals*



Left versus Right



Infundibulum



Spiervezel orientatie van de RV





RV geometrie en functie

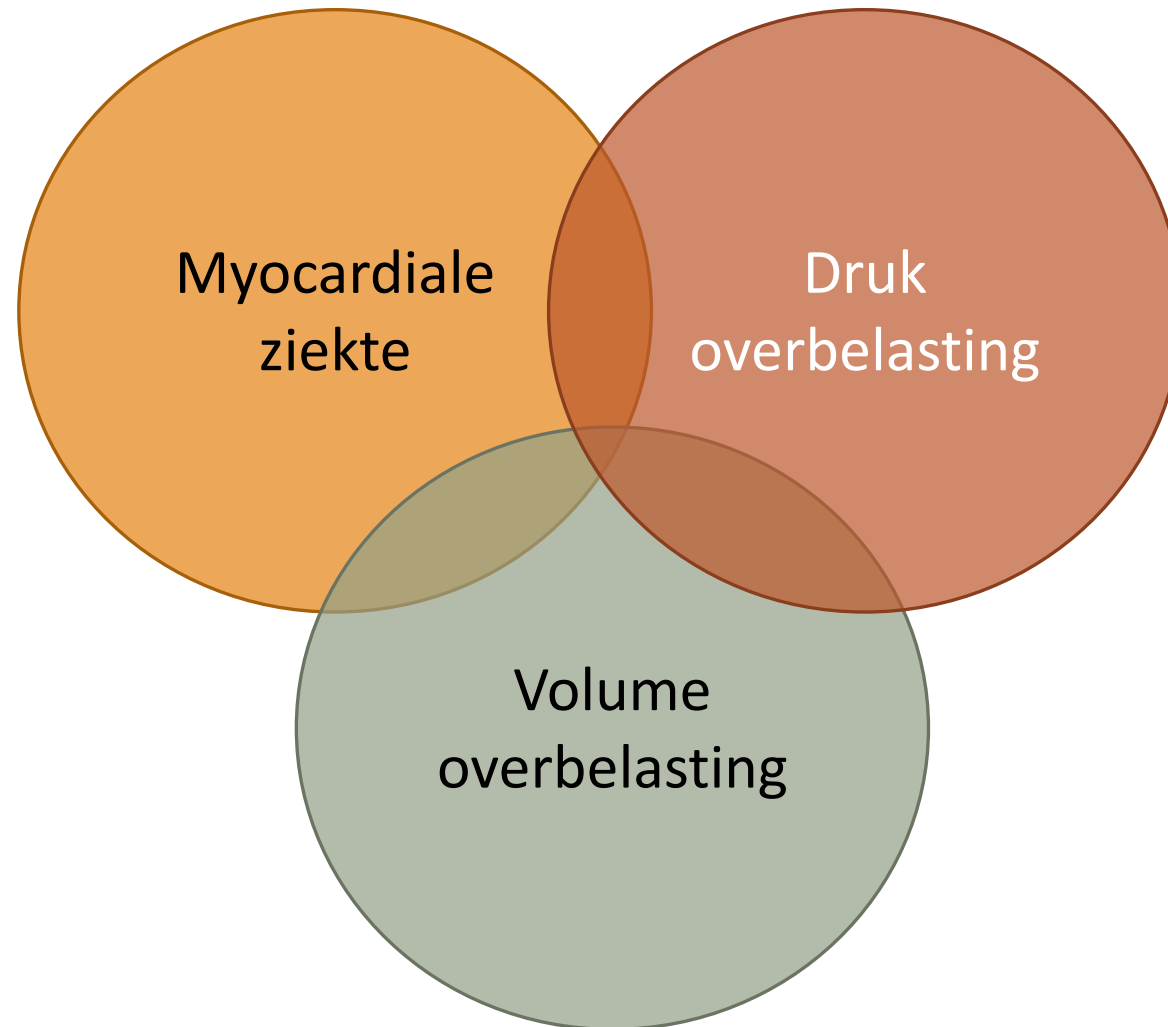
RV functie wordt bepaald door:

- ✓ *Longitudinal shortening*: TV annulus trekt richting de apex
- ✓ Binnenwaardse beweging RV vrije wand (blaasbalg effect)
- ✓ Infundibulaire contractie aan het einde van de systole

Interventriculaire dependency:

- ✓ LV contractie via het gezamenlijke IVS
- ✓ continuïteit van circumferentiele myofibrillen

RV pathofysiologie



Jenny White

Koken met 3 ingrediënten

200 fantastische,
makkelijke
recepten uit de
minimalistische
keuken

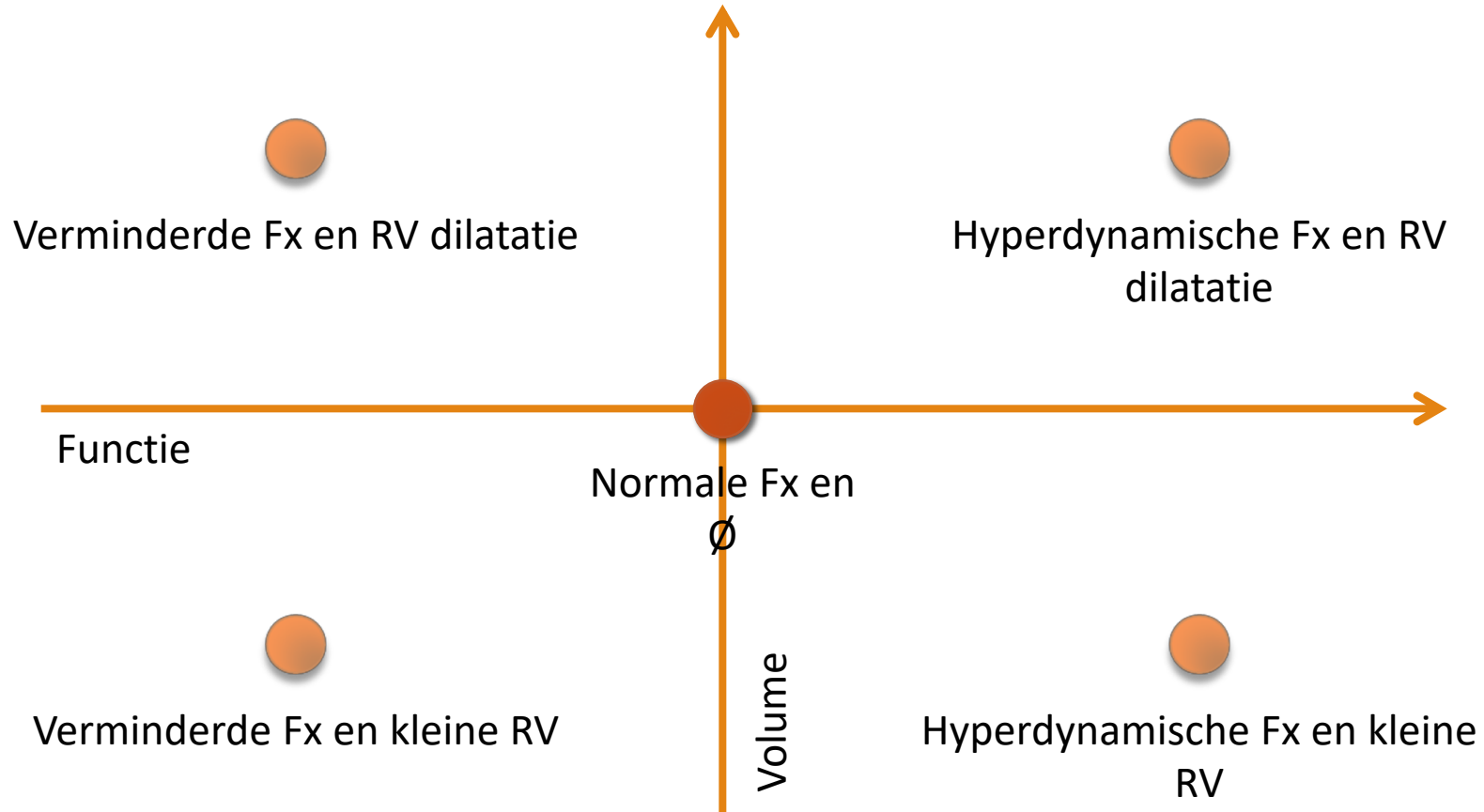


Veltman Uitgevers

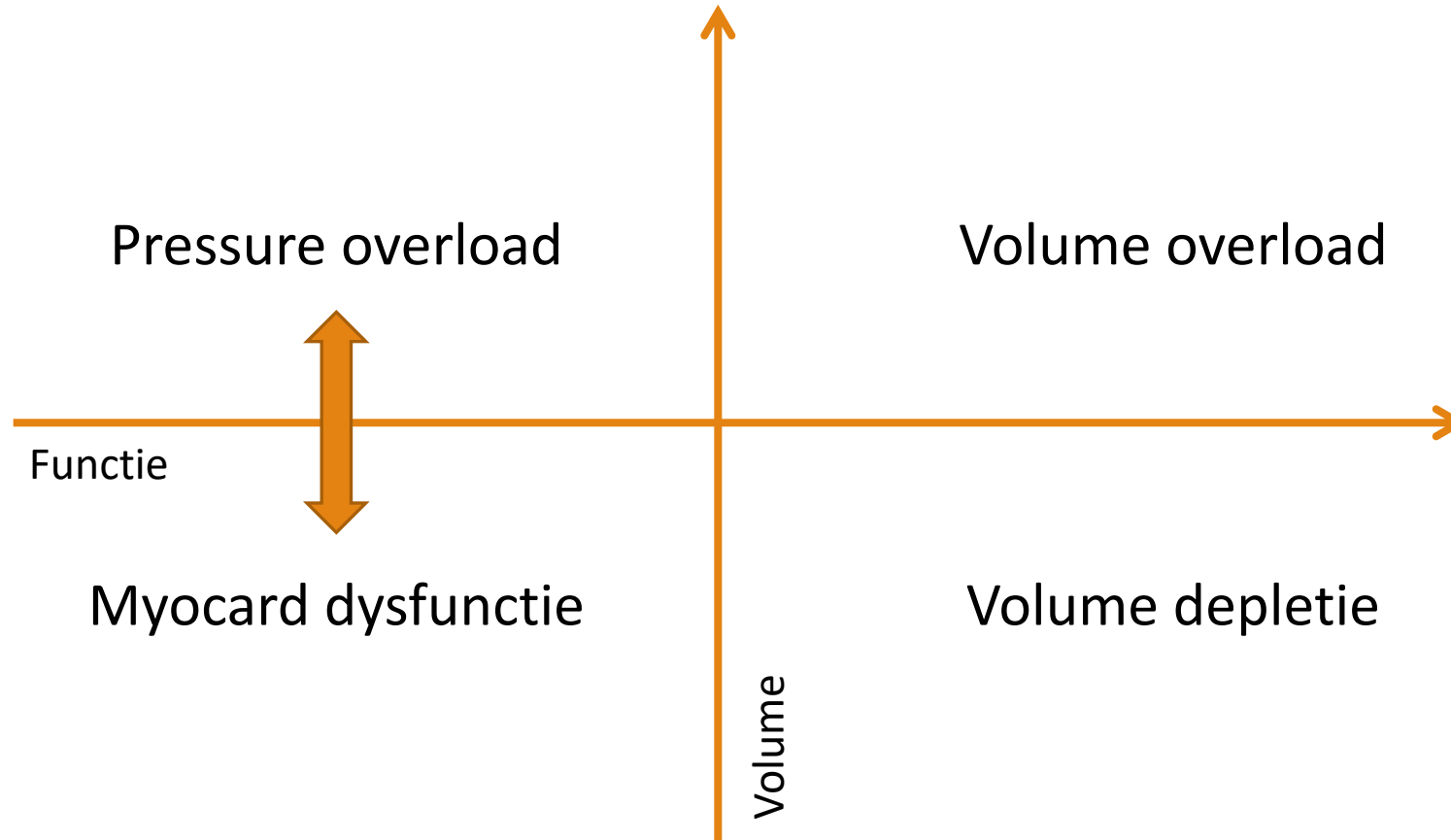
Voor de diagnostiek van de RV heb je nodig:

- Dimensie van de RV
- Functie van het myocard
- Schatting van de drukken

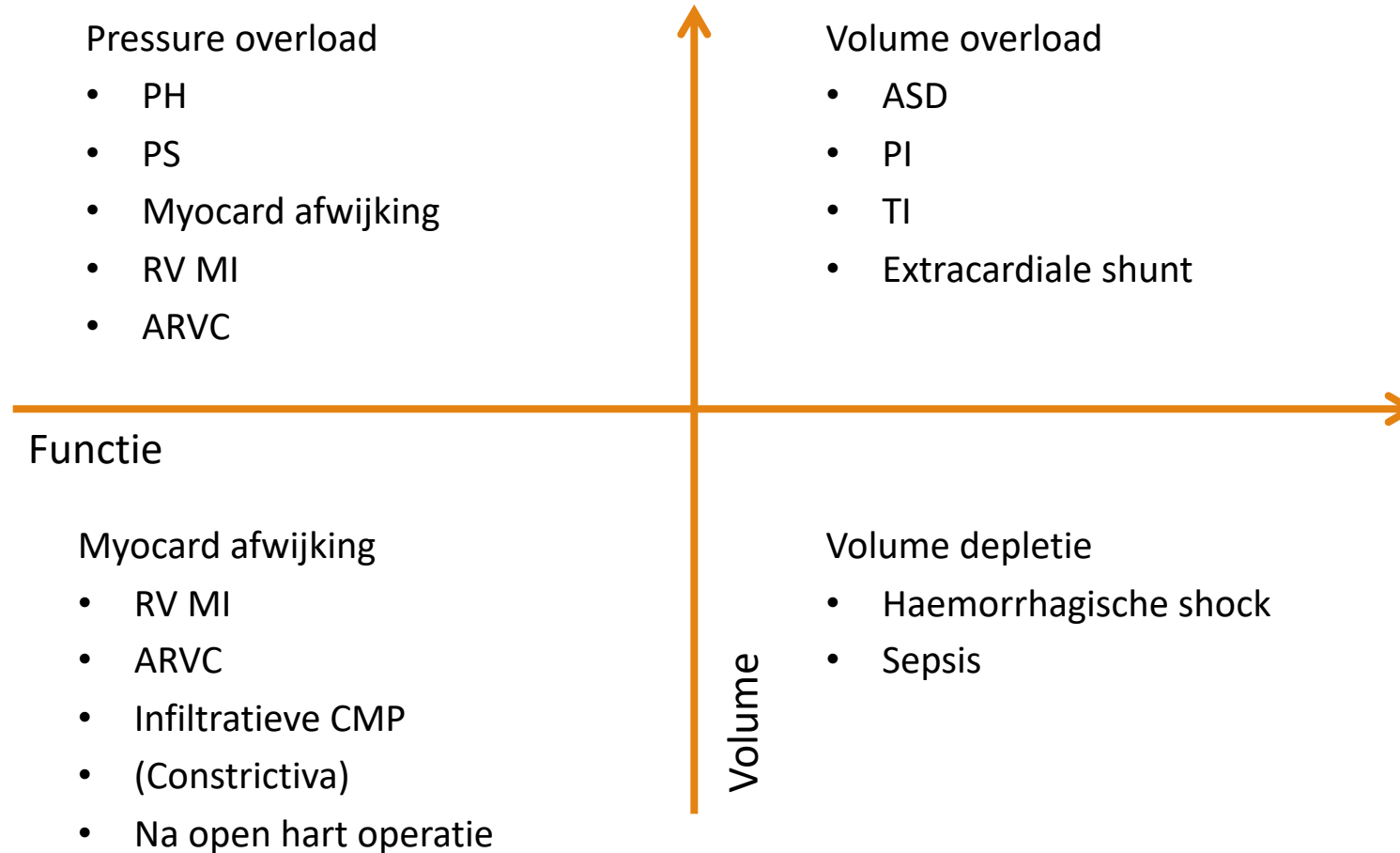
Het quadrant van de RV diagnostiek



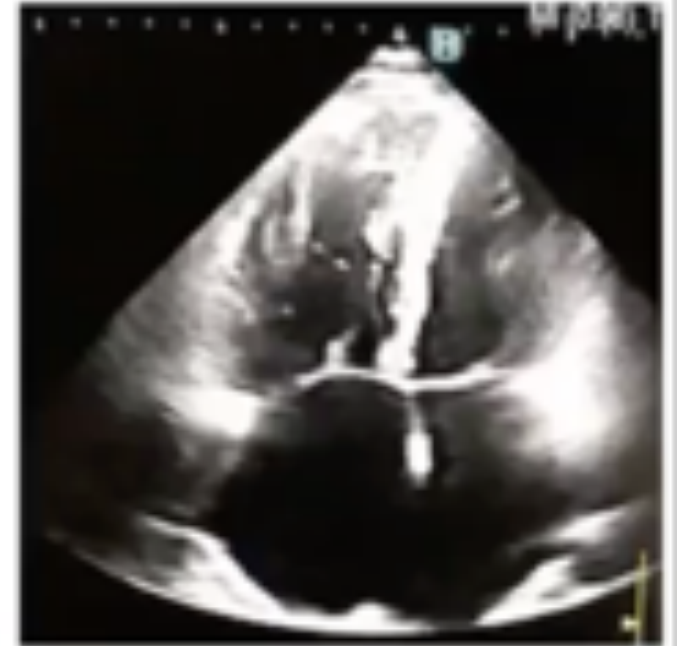
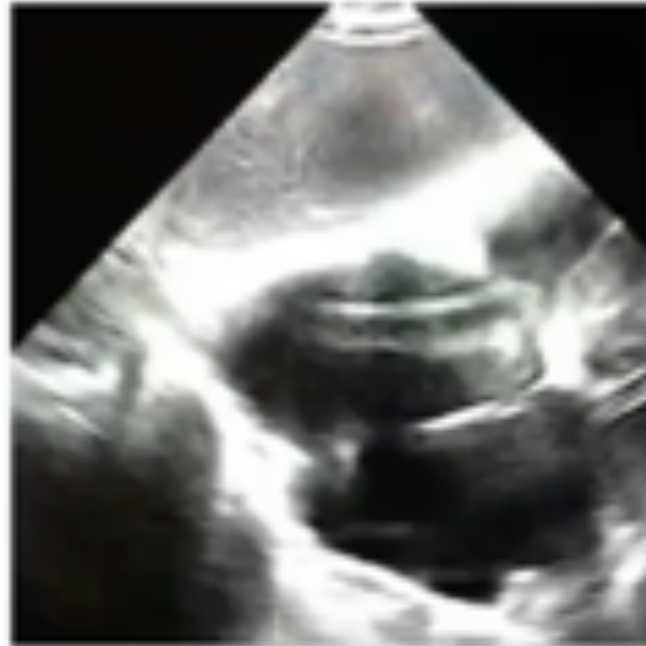
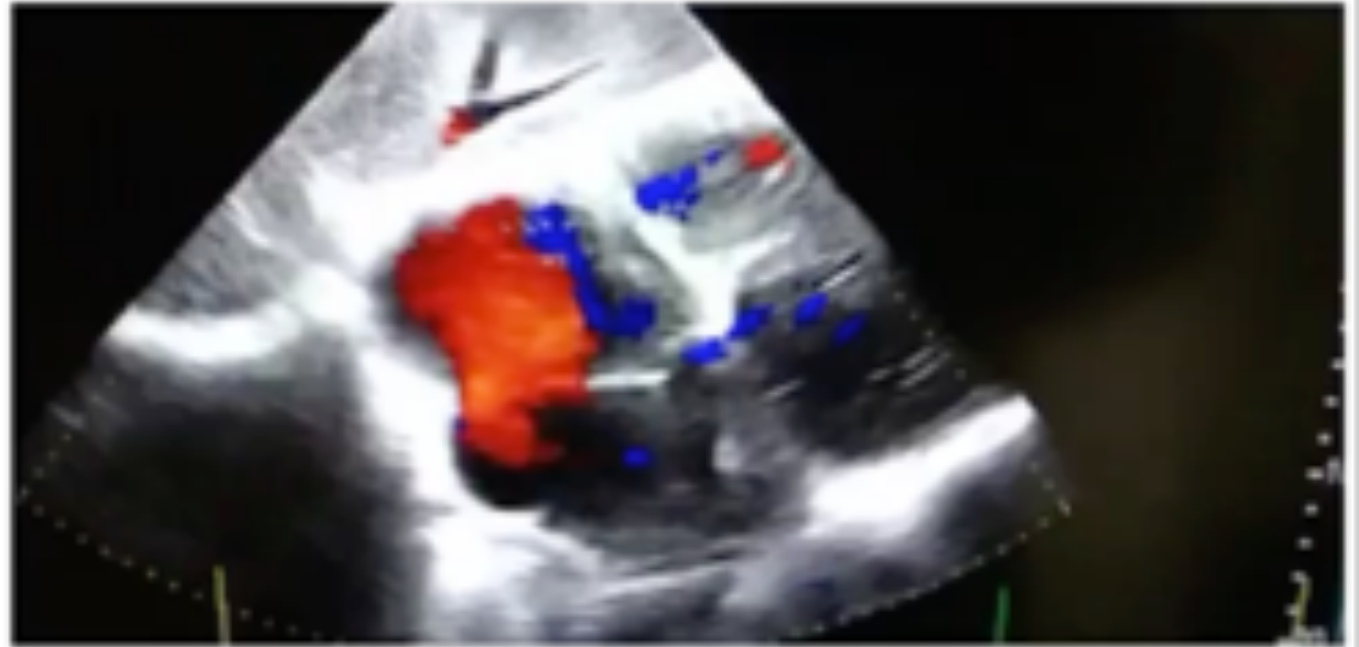
De Pathofysiologie



Verfijning diagnostiek



ASD volume
belasting RV



Quantificatie van RV diameter en functie

TABLE 1 Summary of Doppler Echocardiographic Parameters and Criteria Used for the Identification of RV Dilatation and Dysfunction

	Threshold for Abnormal Value	Limitations
RV basal diameter	>41 mm	Dependent on probe rotation
RV mid cavity diameter	>35 mm	Dependent on probe rotation, no isolated reference point
RV base to apex diameter	>38 mm	Identification of the apical point, dependent on probe rotation
RV free wall thickness (subcostal or P/LA view)	>4 mm	Endocardial border definition (interobserver)
LV eccentricity index	>1	
Fractional area change	<35%	Endocardial border definition
TAPSE	<17 mm	Dependent on alignment with RV free wall, less accurate in case of free TR
Peak E wave velocity of the tricuspid annulus	<9.3 cm/s	Dependent on alignment with RV free wall, less accurate in case of free TR
Myocardial performance index	PM Doppler <0.45, PM TDI <0.54	Angle dependent
RV free wall longitudinal strain	<-20%	Dependent on image quality (angle dependency of TDI)
3D echocardiography		
RV ejection fraction	<40%	Dependent on image quality, endocardial border definition
RV end-diastolic volume	>87 (M) or 74 (F) mL/m ²	
RV end-systolic volume	>46 (M) or 34 (F) mL/m ²	

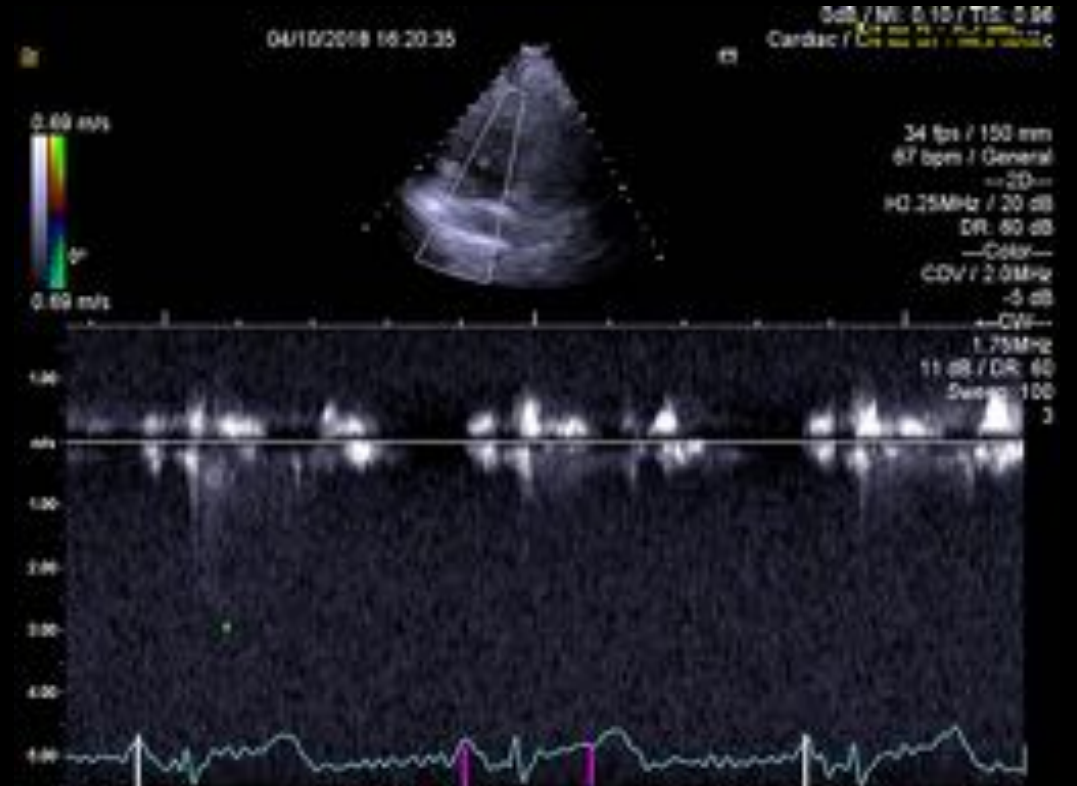
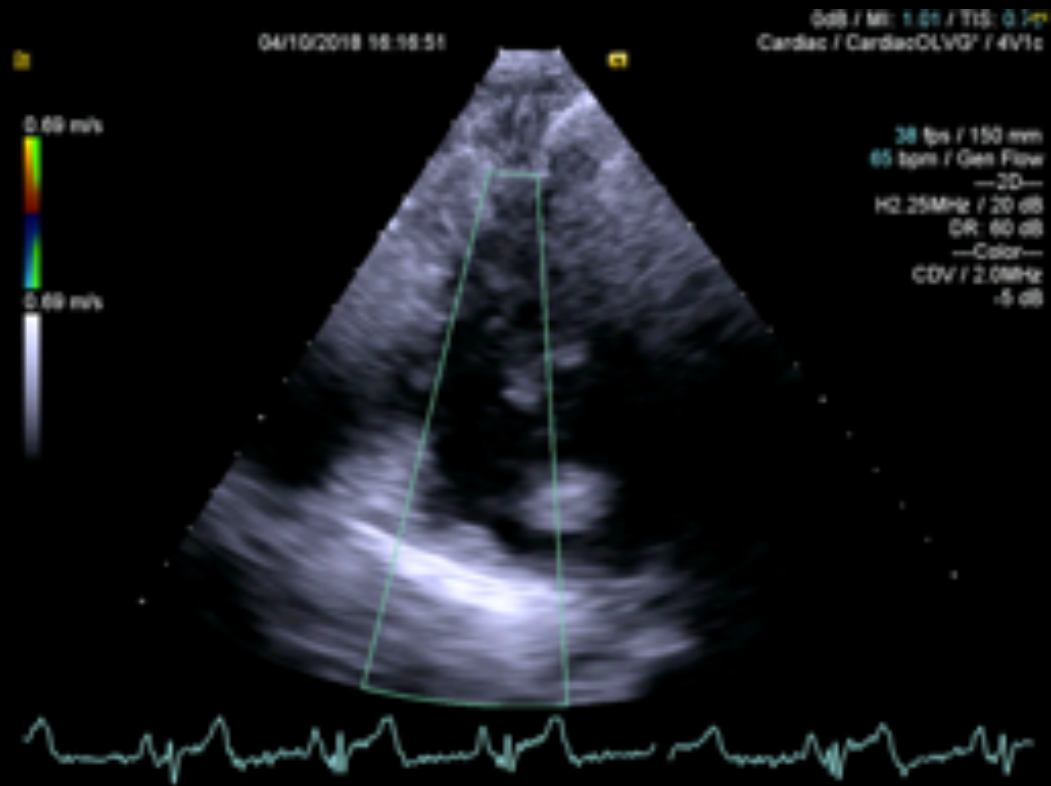
Reference ranges are derived from the Recommendations of Chamber Quantification published jointly by the American Society of Echocardiography and the European Association of Cardiovascular Imaging (1).

3D = 3-dimensional; E = E-wave velocity; M = male (mean); P/LA = parasternal long axis; PM = pulsed wave; TAPSE = tricuspid annular plane systolic excursion; TDI = tissue Doppler imaging; TR = tricuspid regurgitation; other abbreviations as in Table 1.

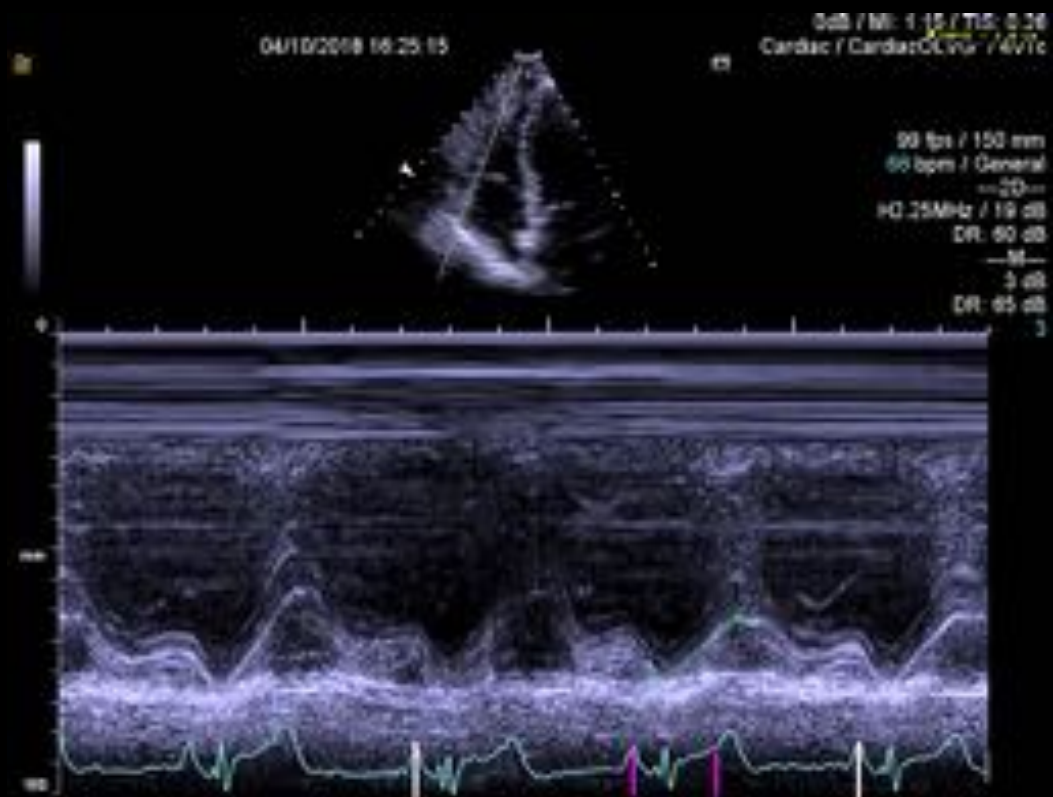
Drukoverbelasting bij PH



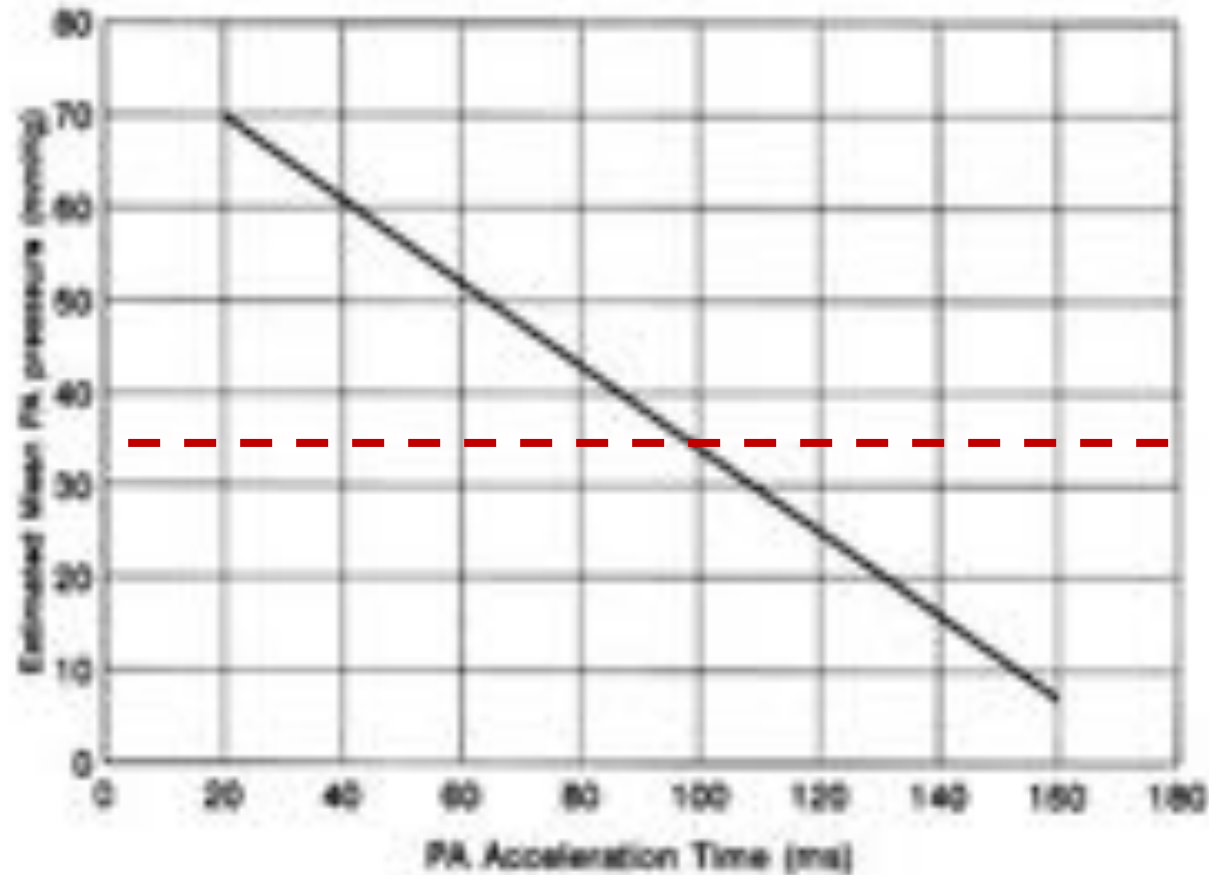
Drukmeting via TR vmax



TAPSE en RV Acc tijd



RVOT PW: AP flow acceleratietijd



AT < 100 m/s: verdenking PH
 mPAP: $79 - (0.45 \times \text{RVOT AT})$

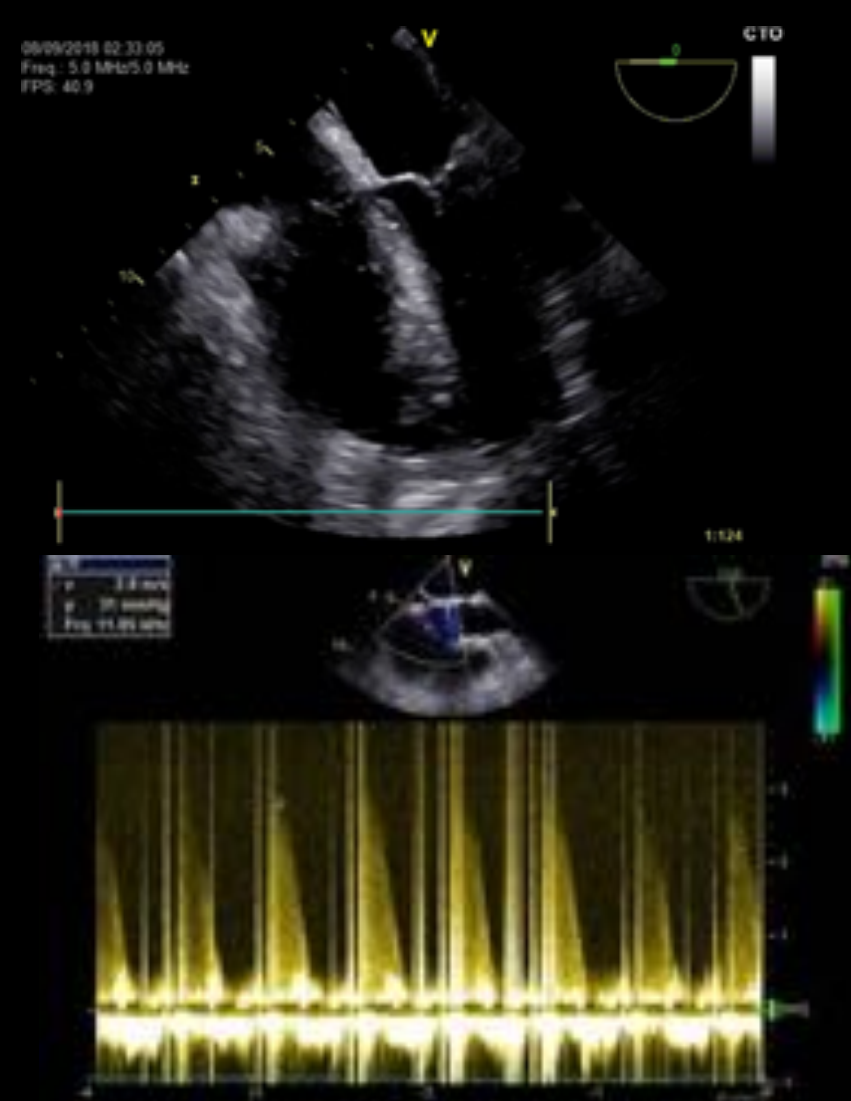
Echografische evaluatie van pulmonaal drukken

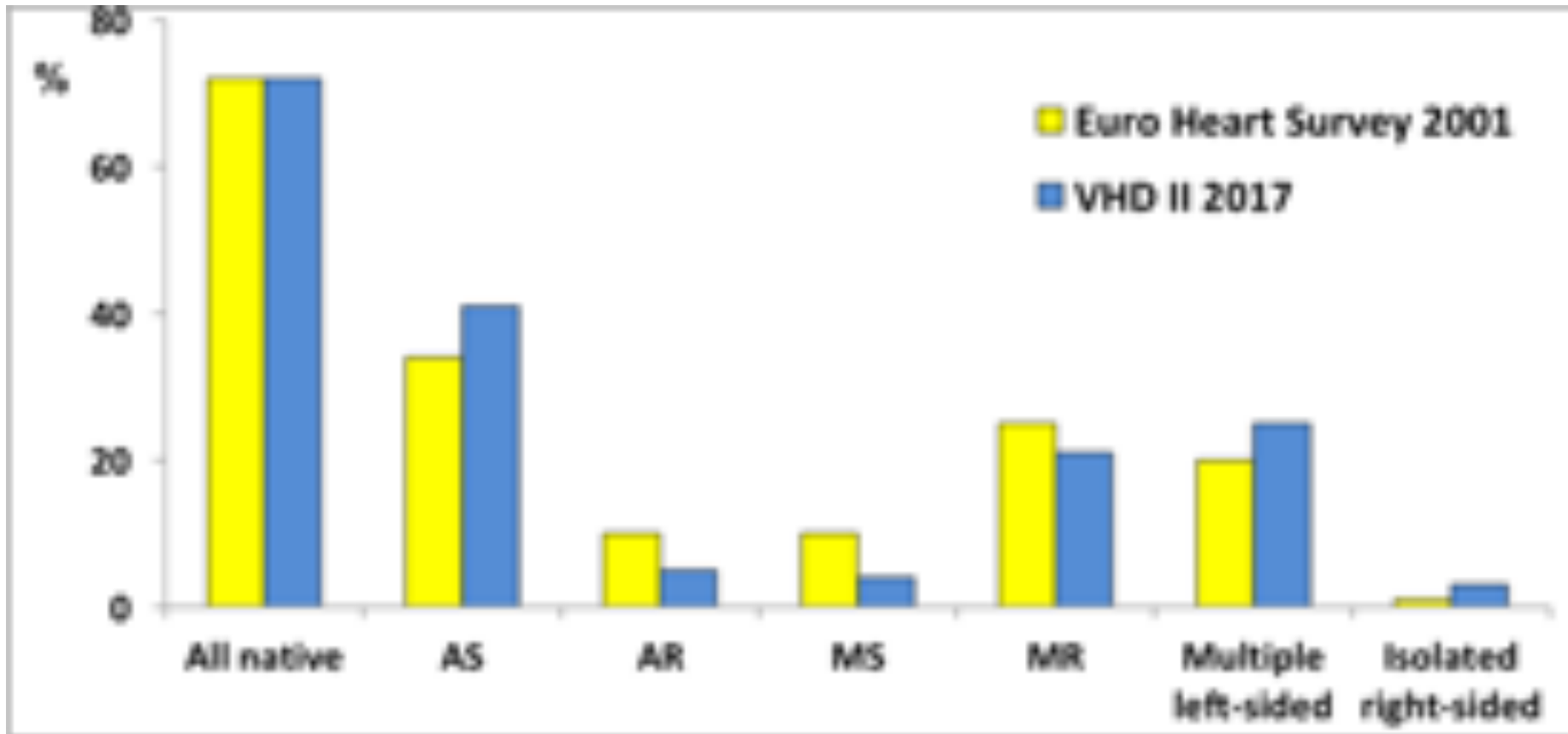
Table 1 Echocardiographic features used for diagnosing pulmonary hypertension					
Peak TR Velocity (sPAP)	Inferior VC	RV vs LV RA Area	Septal Wall	Pulmonary AT	Likelihood of PH
≤2.8 m/s (≤36 mm Hg)	≤2.1 cm inspiratory collapse >50%	RV < LV RA area <18 cm ²	Normal	>105 ms	Unlikely/low
≤2.8 m/s (≤36 mm Hg)	>2.1 cm inspiratory collapse <50%	RV ≥ LV RA area ≥18 cm ²	Fluttering Abnormal septal motion	<105 ms	Intermediate
2.9–3.4 m/s (37–50 mm Hg)	≤2.1 cm inspiratory collapse >50%	RV < LV size RA area <18 cm ²	Normal	>105 ms	
2.9–3.4 m/s (37–50 mm Hg)	>2.1 cm inspiratory collapse <50%	RV ≥ LV RA area ≥18 cm ²	Fluttering Abnormal septal motion	<105 ms	High
>3.4 m/s (>50 mm Hg)	Presence or not of supportive signs				

Invloed van PH op RV dimensie en functie



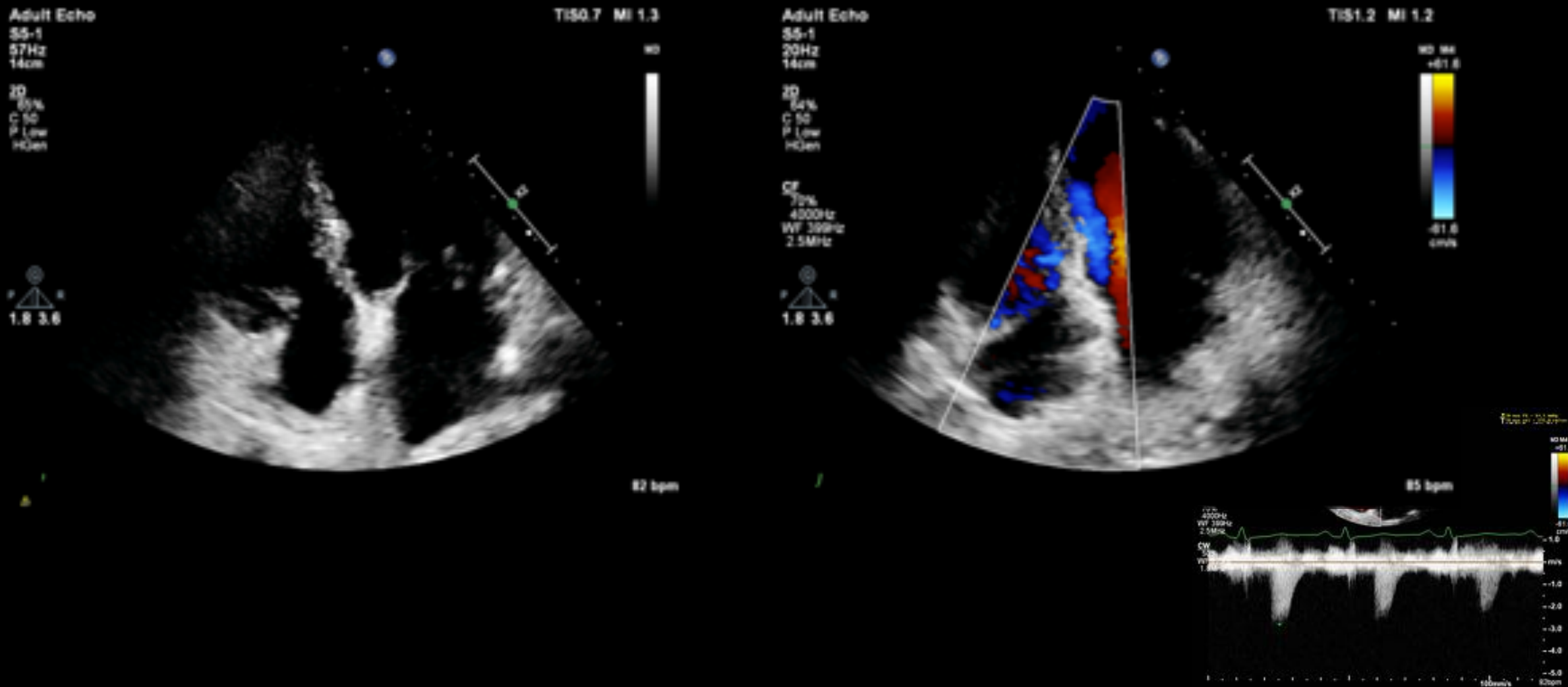
VA ECMO weanen

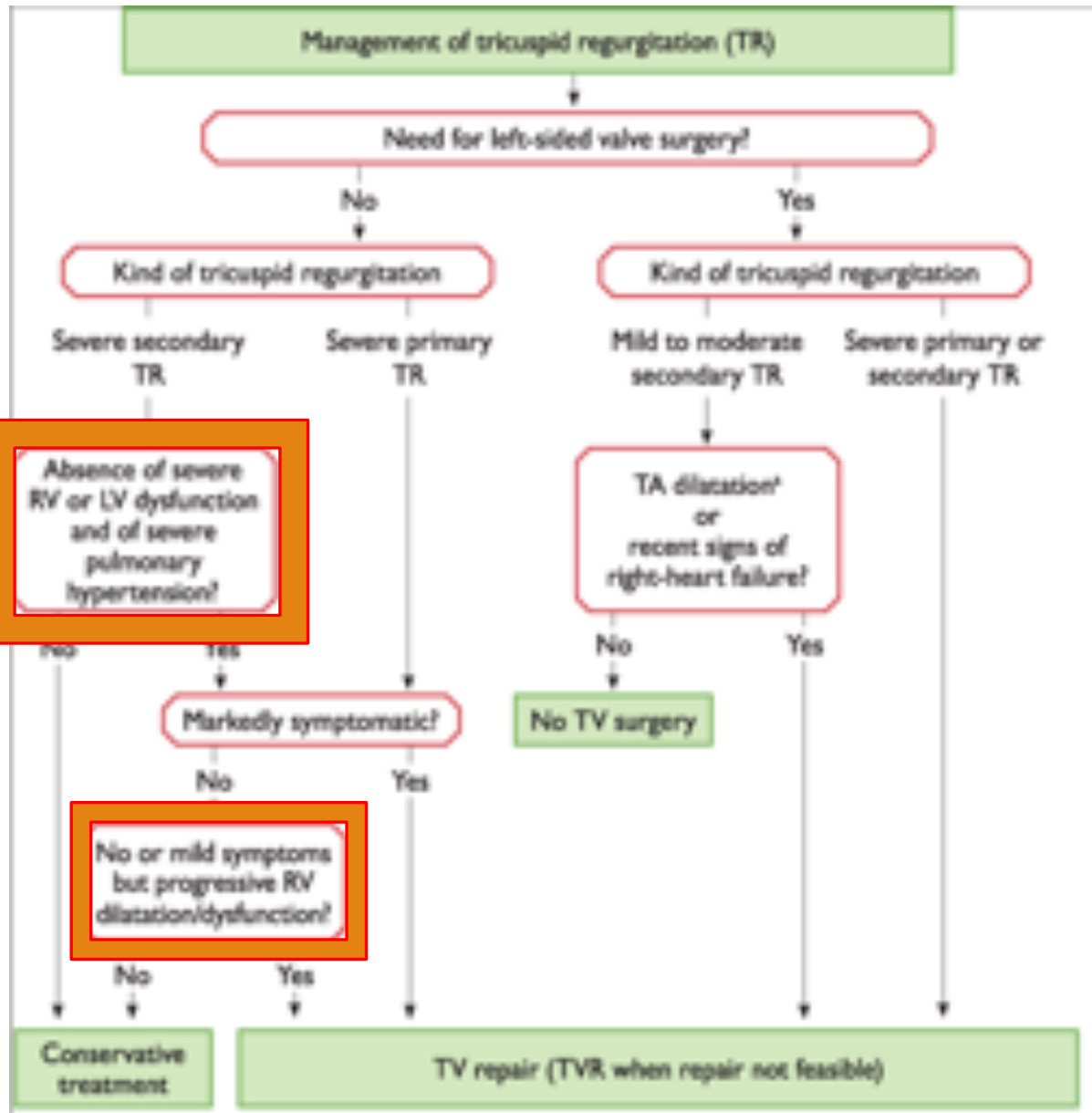




EORP VHD II registry: Distributie natief kleplijden

Volume belasting RV bij TI (prolaps)



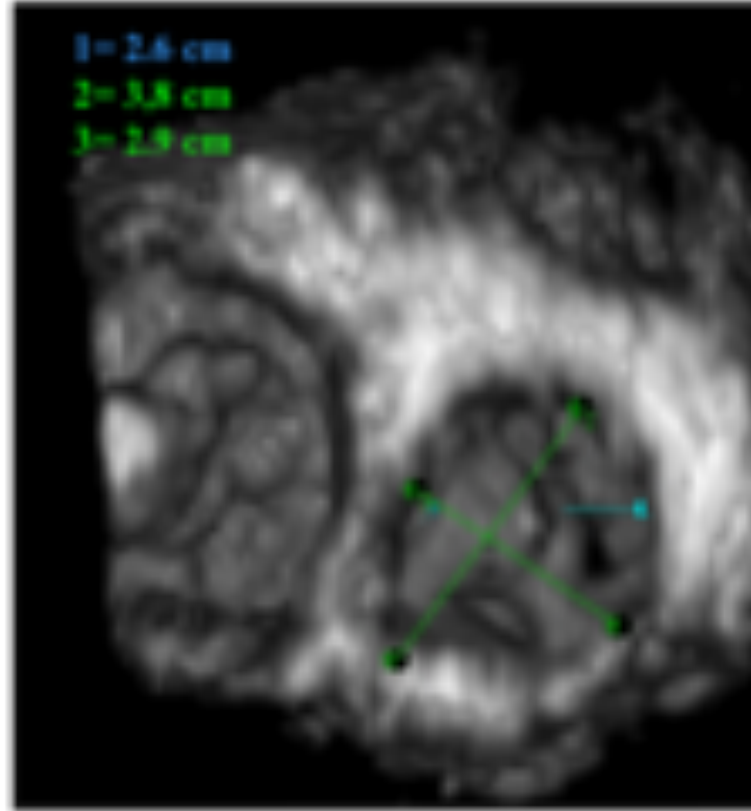
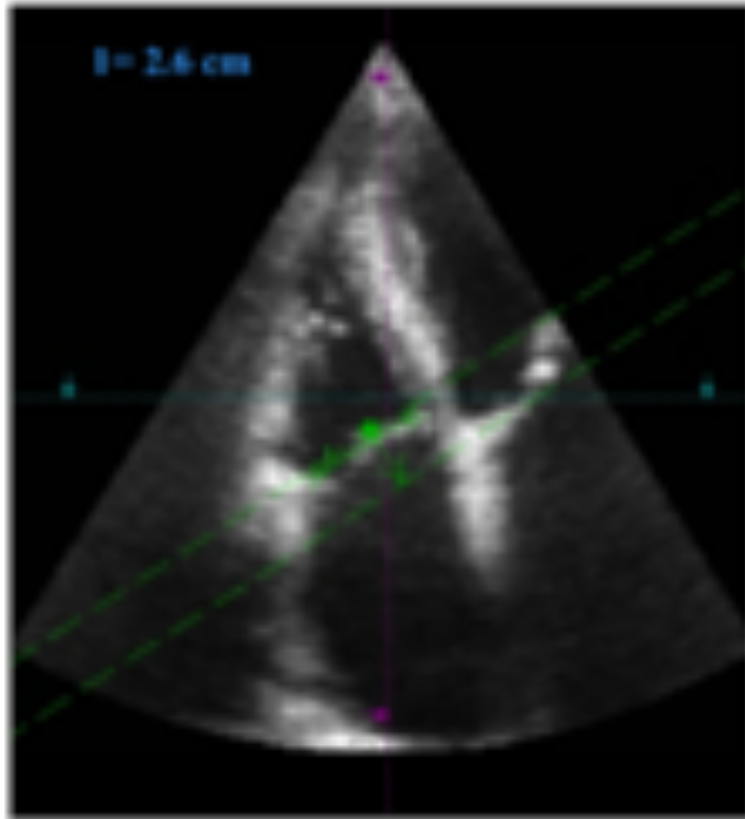


Invloed RVF/PH op besluitvorming bij TI

1. Ernstige RV disfunctie/PH is een contra-indicatie voor TV repair
2. Bij asymptomatische ernstige TI is progressieve RV dilatatie/dysfunctie juist een indicatie voor TVR

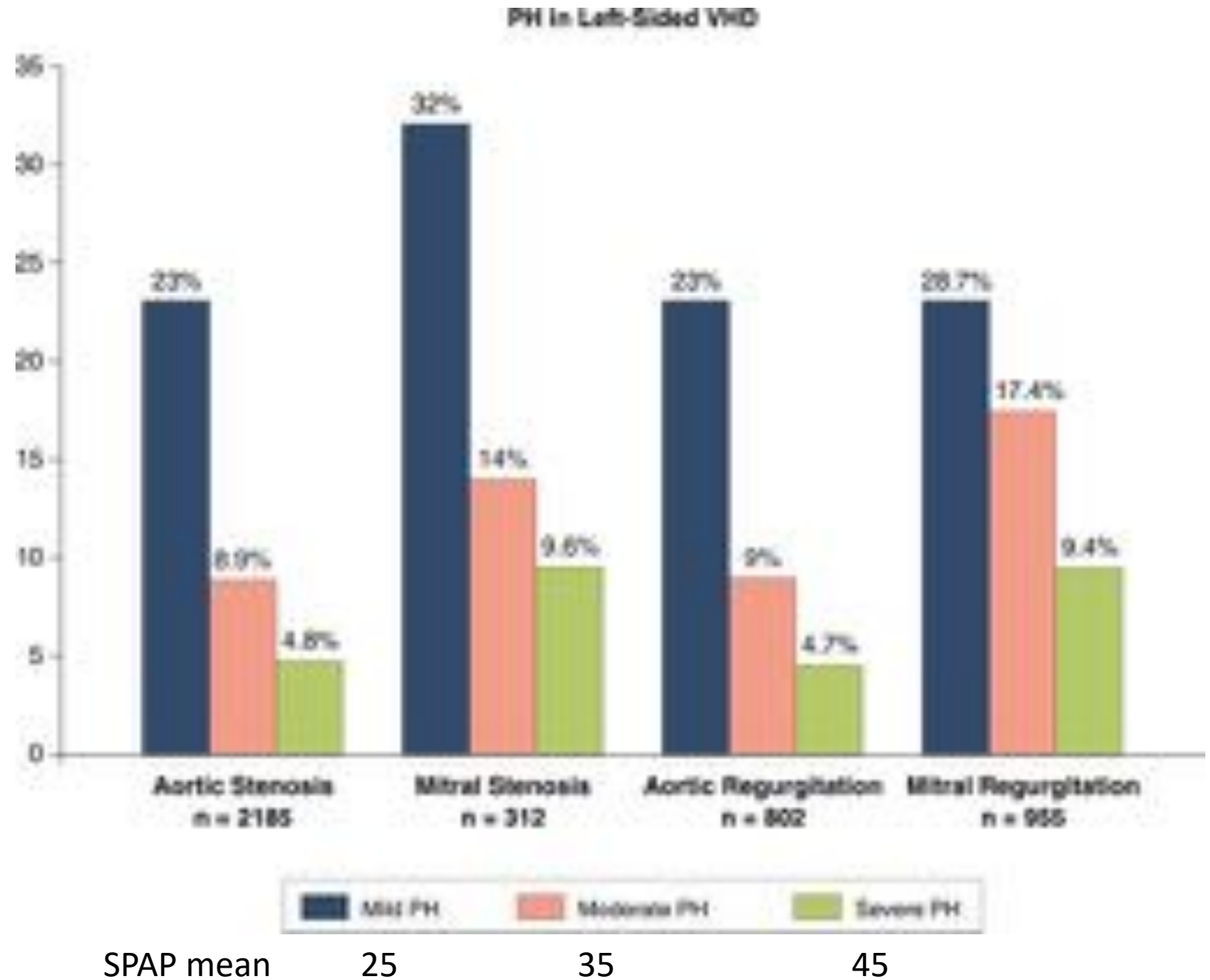
a. TA \geq 40 mm or $>$ 21 mm/m

Juiste meting van de TV annulus



Prevalentie PH in VHD

PH is een klassiek pathofysiologisch gevolg van links-zijdig kleplijden



SPAP mean

25

35

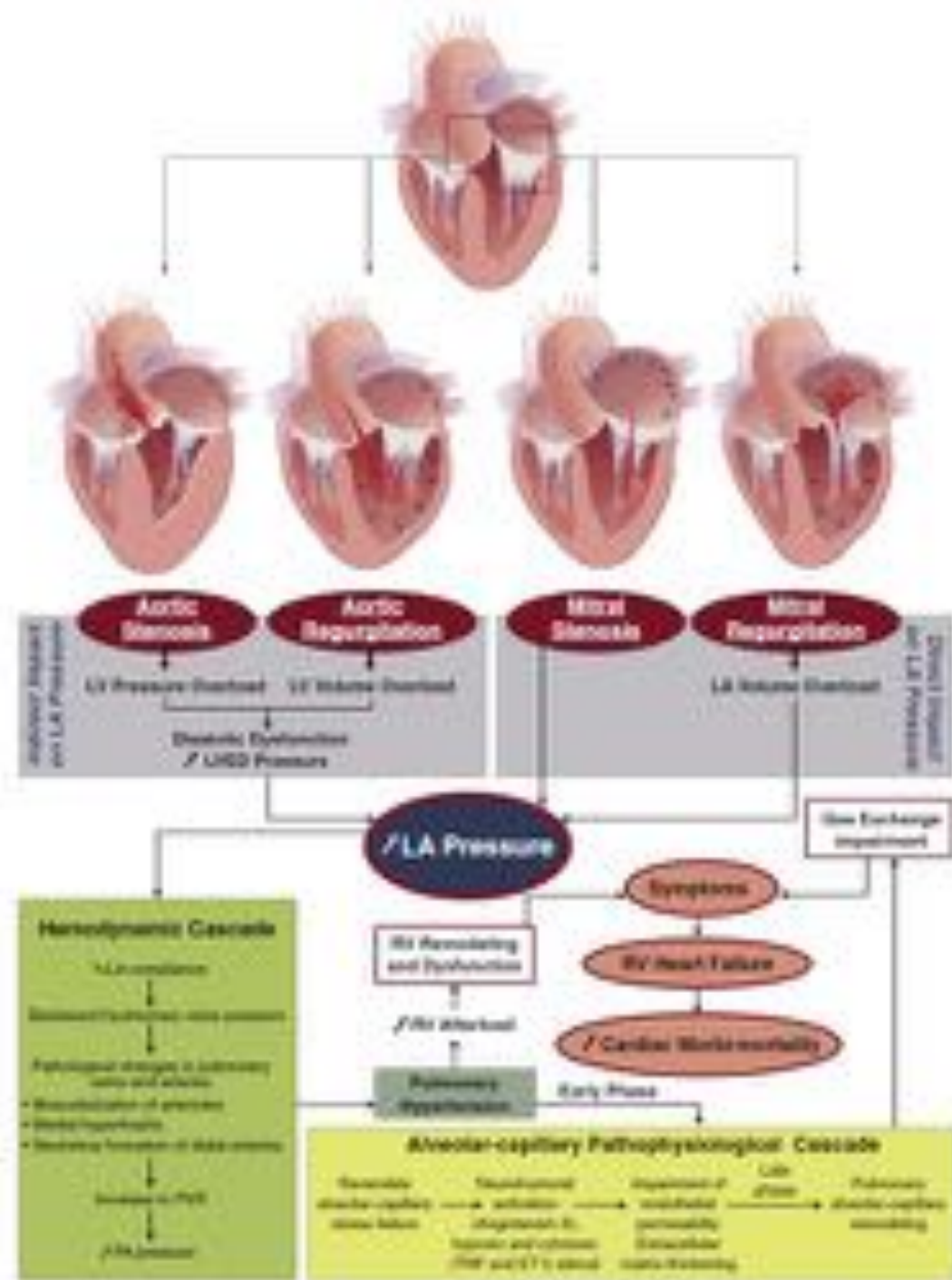
45

Pathofysiologie

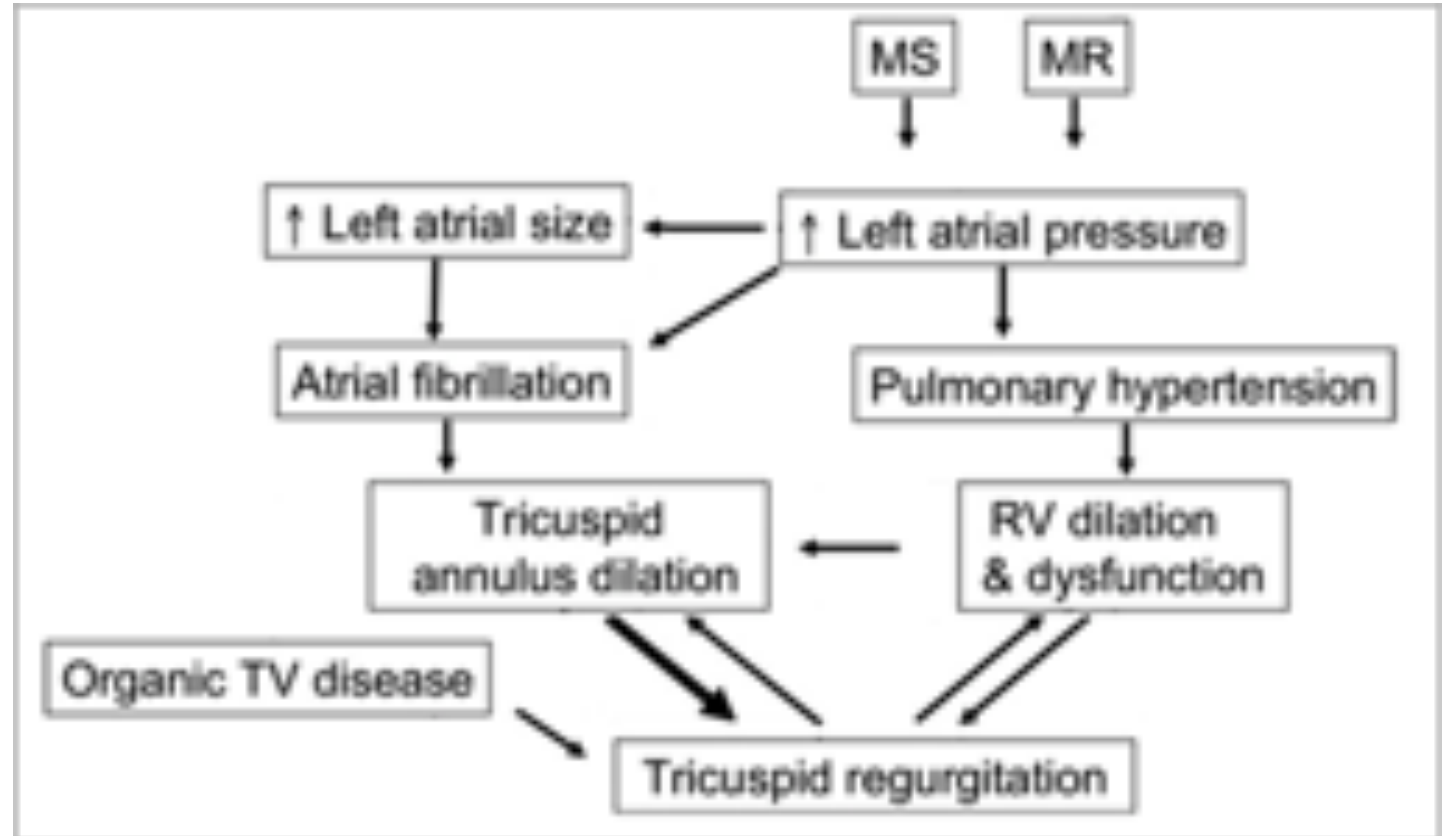
Aorta en mitralisklep ziekten gaan vaak gepaard met PH, vooral wanneer ze ernstig zijn en symptoomatisch

In niet-symptomatische patiënten is PH zeldzaam

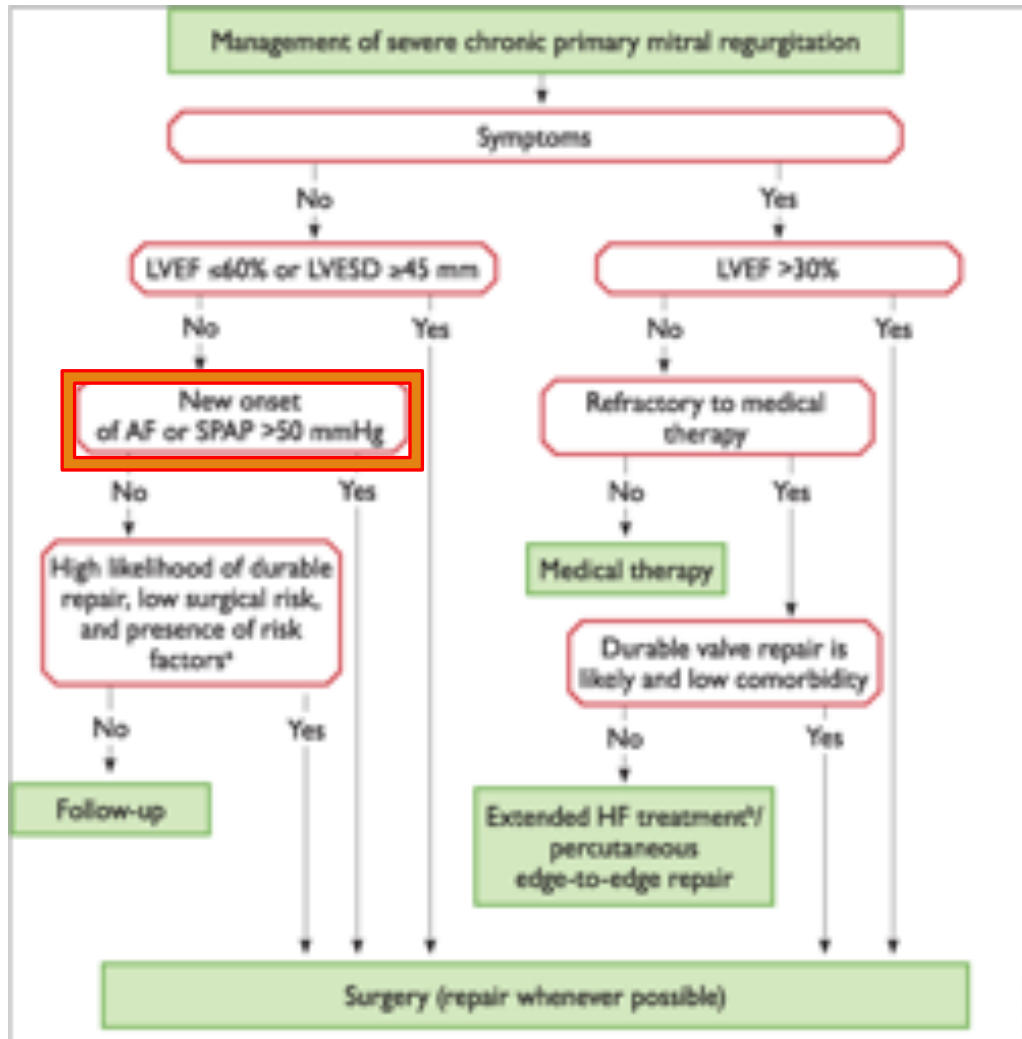
VHD kan direct of indirect de LA druk verhogen



Pathogenese van TR bij mitraliskleplijden



PH and management of MR



Invloed RVF/PH op besluitvorming bij MI

1. Bij asymptomatische ernstige MI met behouden LVF en dimensie is PH een indicatie voor MVR

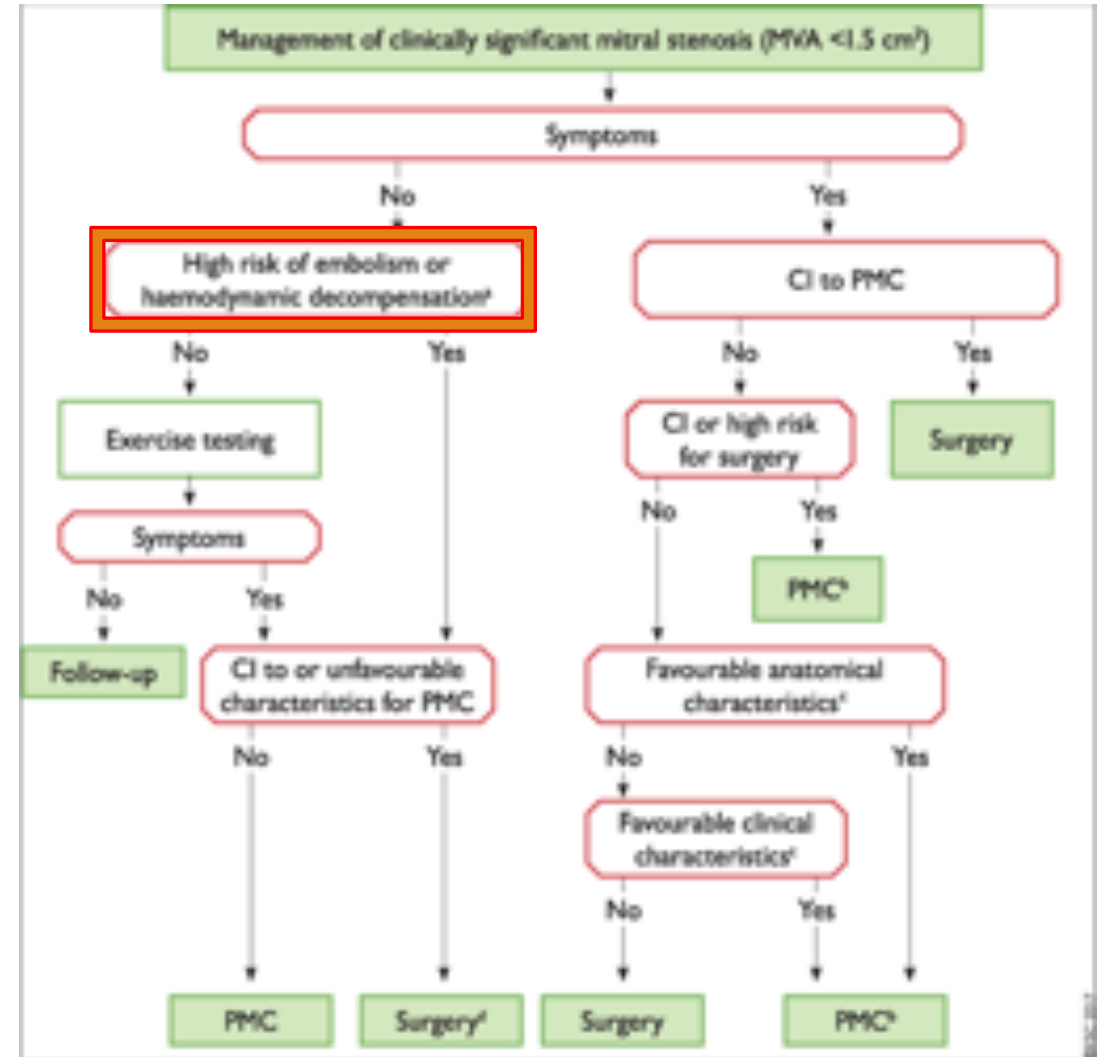
PH and management of MS

Invloed RVF/PH op besluitvorming bij MS

1. Bij asymptomatische matig/ernstige MS is PH een indicatie voor PMC/MVR

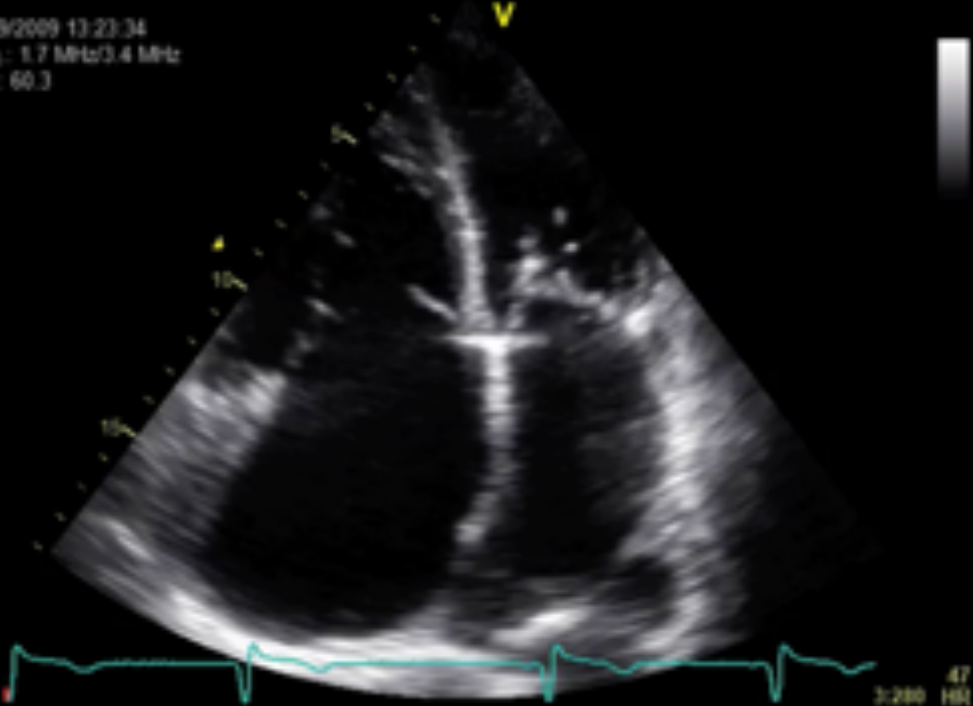
High-risk of haemodynamic decompensation:

- ✓ *Systolic pulmonary pressure >50 mmHg at rest*
- ✓ Need for major non-cardiac surgery
- ✓ Desire for pregnancy

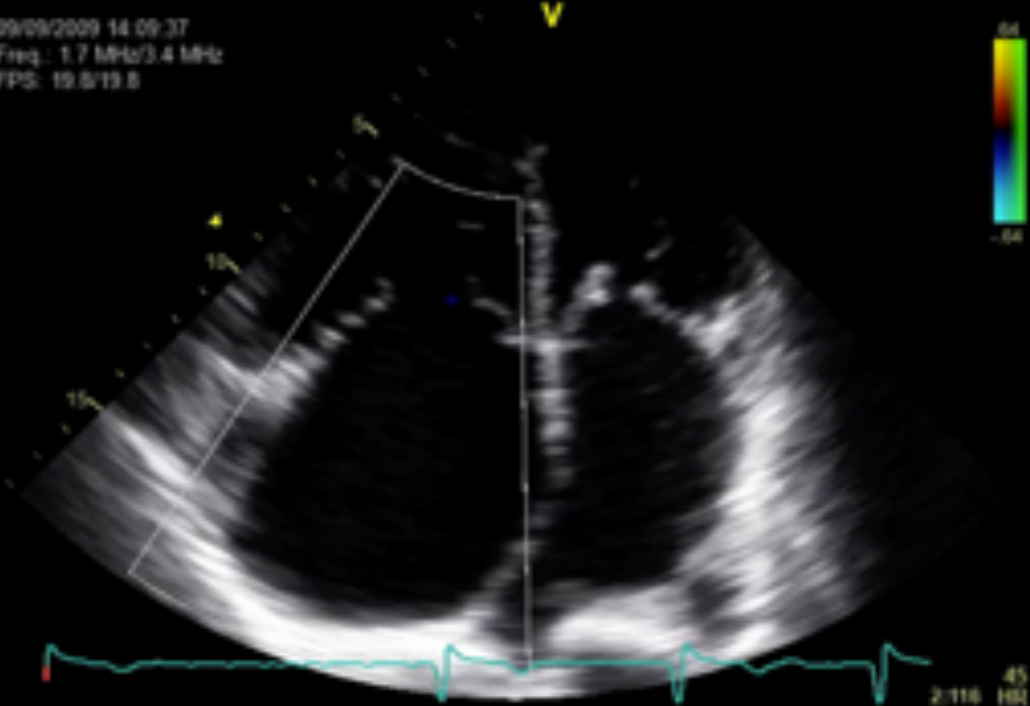


Reumatisch (MI/MS) kleplijden. Gecombineerd druk/volume belasting

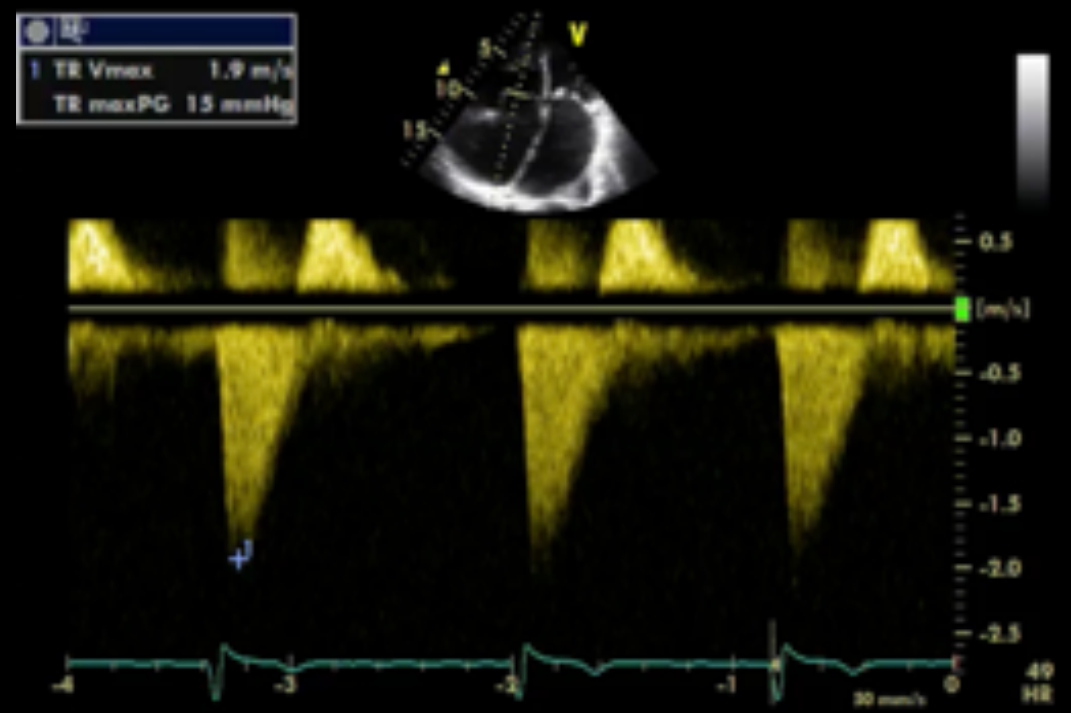
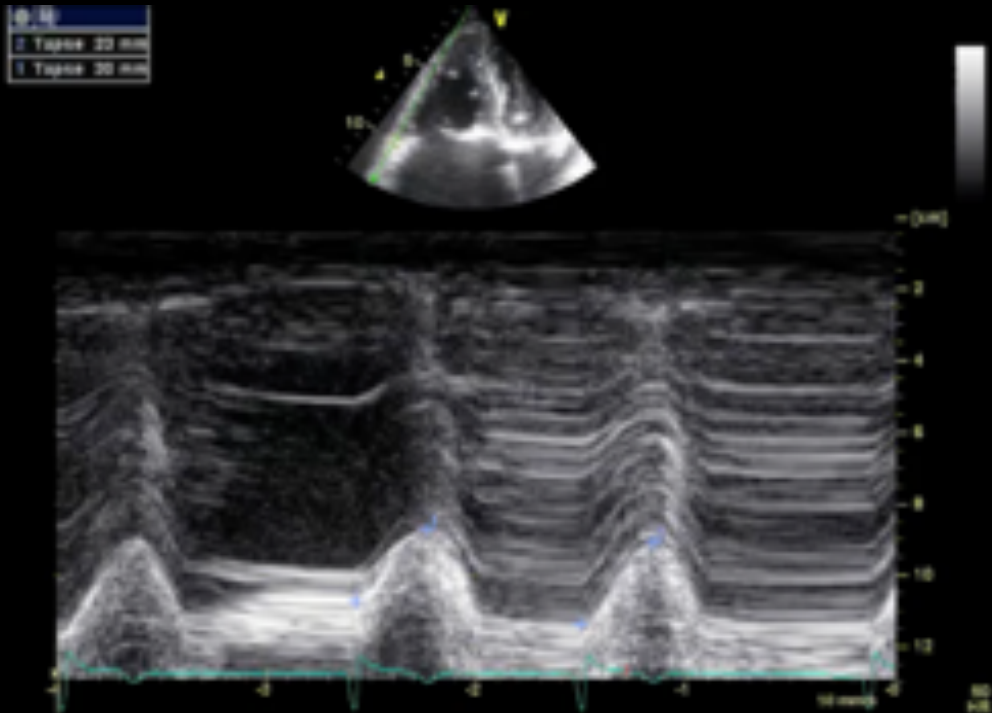
09/09/2009 13:23:34
Freq.: 1.7 MHz/3.4 MHz
FPS: 60.3



09/09/2009 14:09:37
Freq.: 1.7 MHz/3.4 MHz
FPS: 19.8/19.8

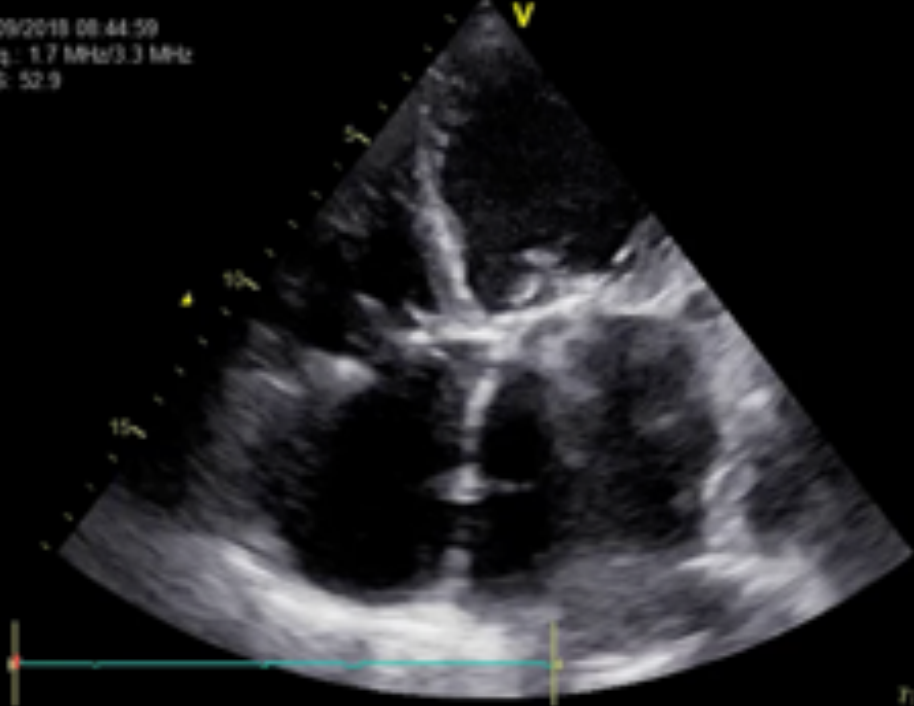


What about TAPSE en TR Vmax

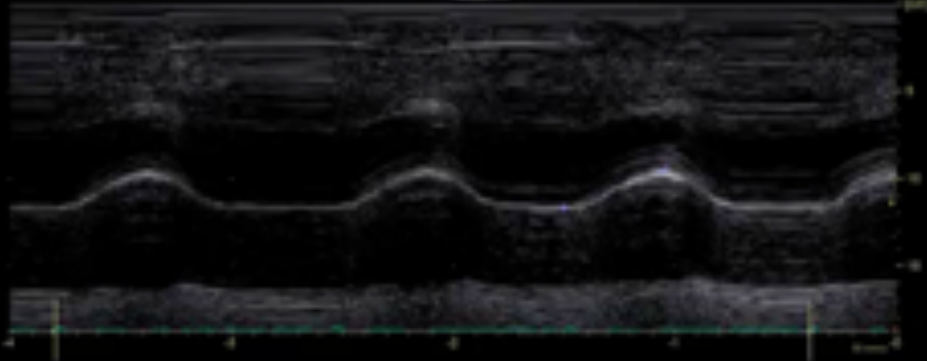
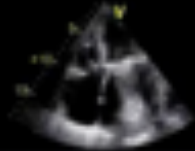


Postoperatieve follow up (MKV, AVR en TVP)

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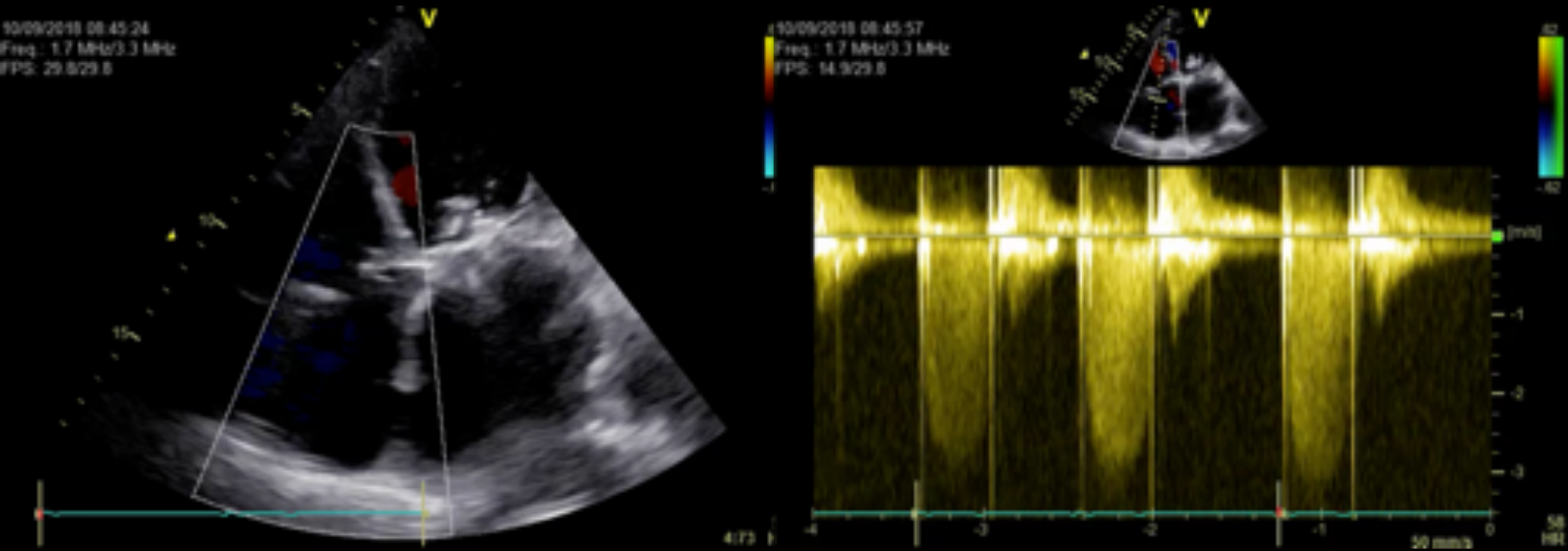


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10.0



2.0

Postoperatieve follow up (MKV, AVR en TVP)



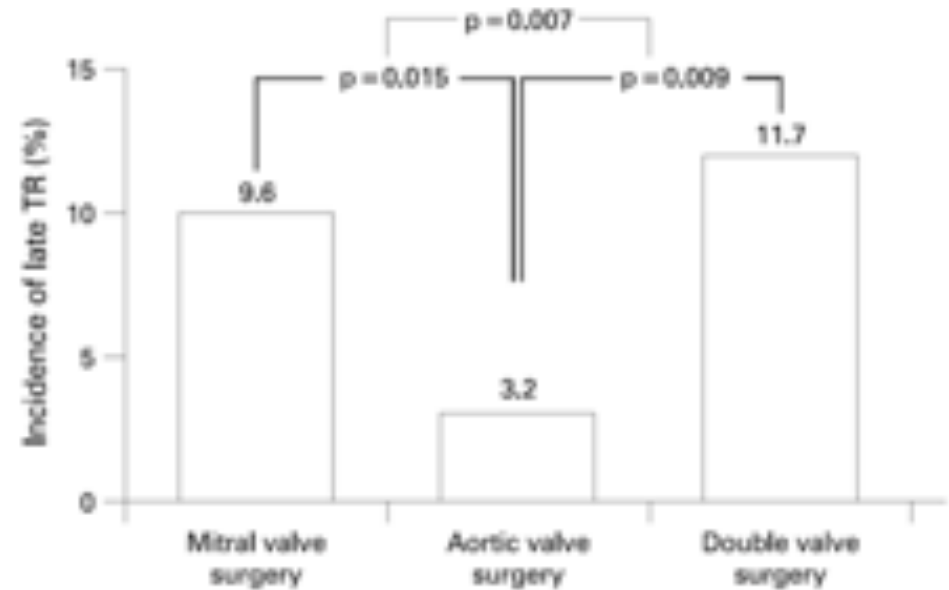
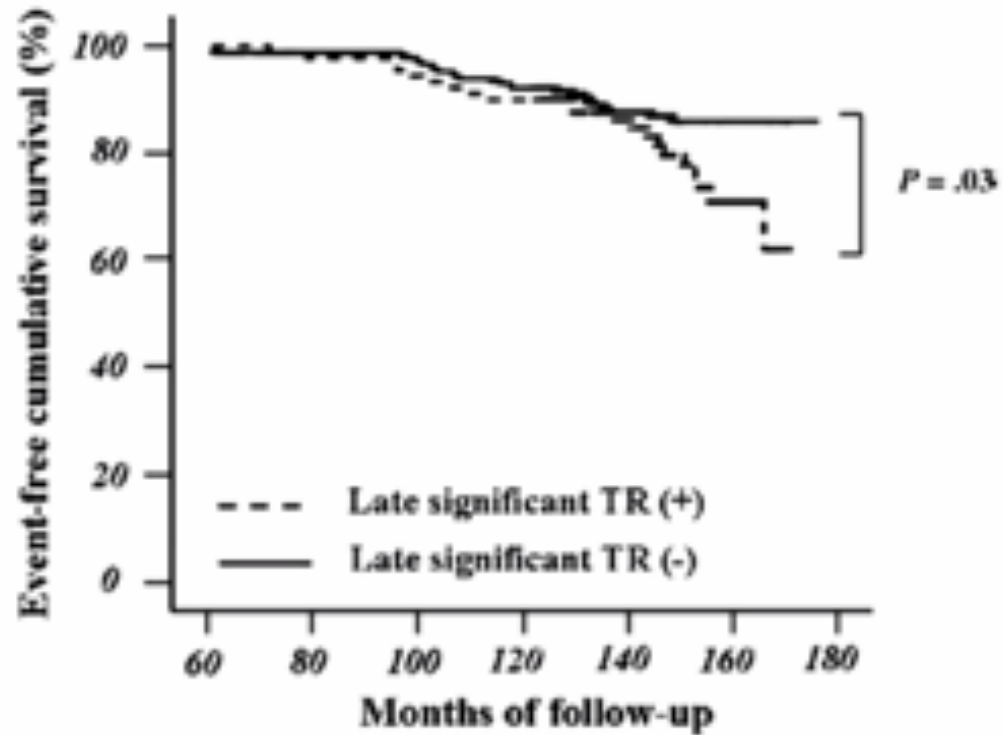


Figure 2 Incidence of late significant tricuspid regurgitation (TR) according to the surgical procedure for the underlying valvular lesion.

Incidentie en impact van rest TI op survival

De rol van het inspanningsecho

Beter timen bij afwezigheid klachten?
Inspannings PH en outcome

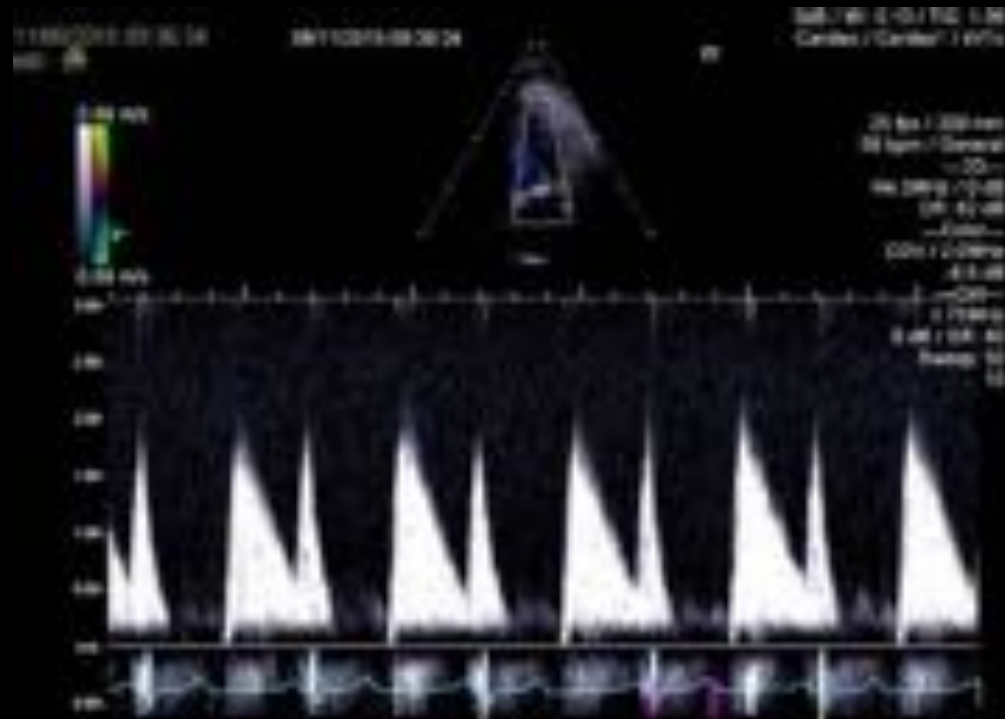
Inconclusieve

Symptomatologie

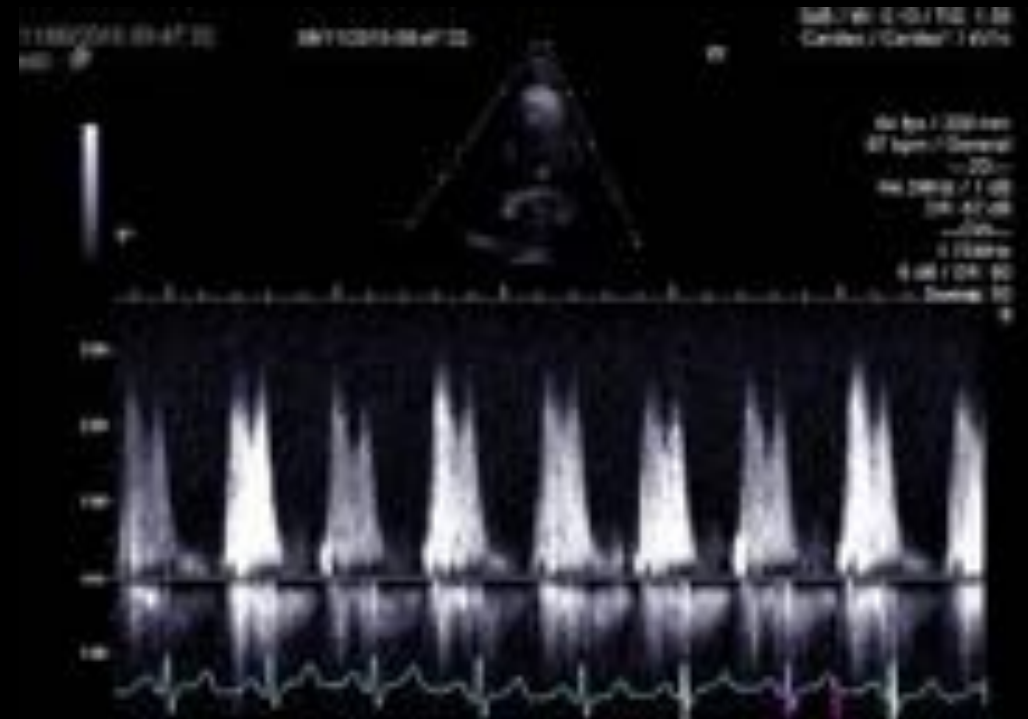
Haemodynamica bij echo



Inspanningsecho



Rust: SR 62bpm, RR 143/91, MV peak 16mmHg, mean 5mmHg. RVSP 30mmHg



MAX 100W: SR 95bpm, RR 172/83, MV peak 30mmHg, mean 17mmHg. RVSP 52mmHg

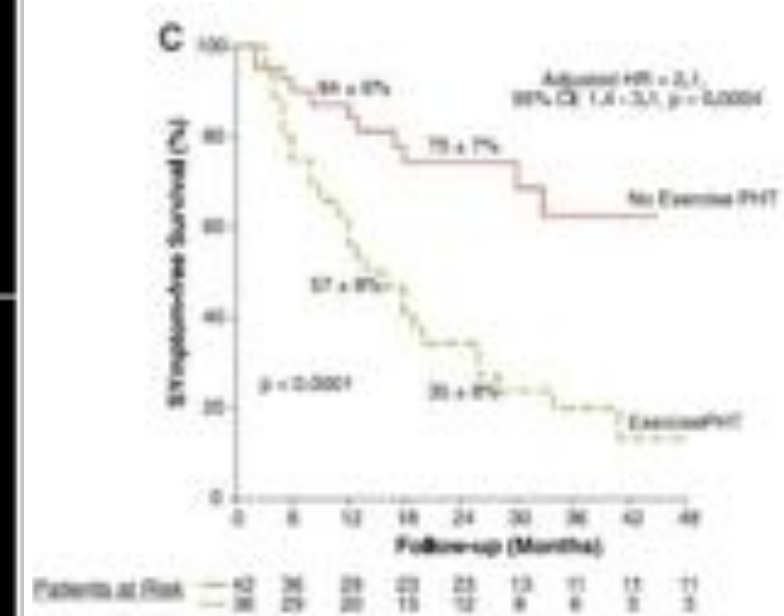
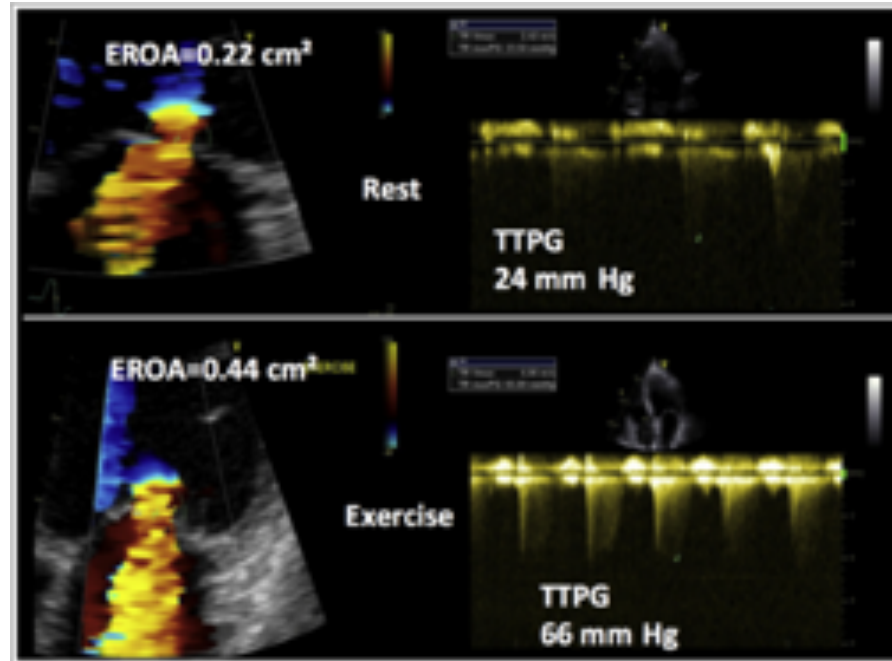
Inspannings echo

1. Inspannings TTE mbv kantel fiets.
2. Toename van MV gradient tijdens inspanning.
3. Rust: SR 62bpm, RR 143/91, MV peak 16mmHg, mean 5mmHg. RVSP 30mmHg
4. 40W: SR 80bpm, MV peak 25mmHg, mean 12mmHg.
5. 80W: SR 90bpm, RR 168/78, MV peak 30mmHg, mean 14mmHg.
6. MAX 100W: SR 95bpm, RR 172/83, MV peak 30mmHg, mean 17mmHg. RVSP 52mmHg
7. Herstel 2min: SR 70bpm, RR 138/77, MV peak 17mmHg, mean 8mmHg.

MI en inspannings PH

Asymptomatic patients with primary moderate and severe MR and EIPH greater than 60 mm Hg might be referred to surgery

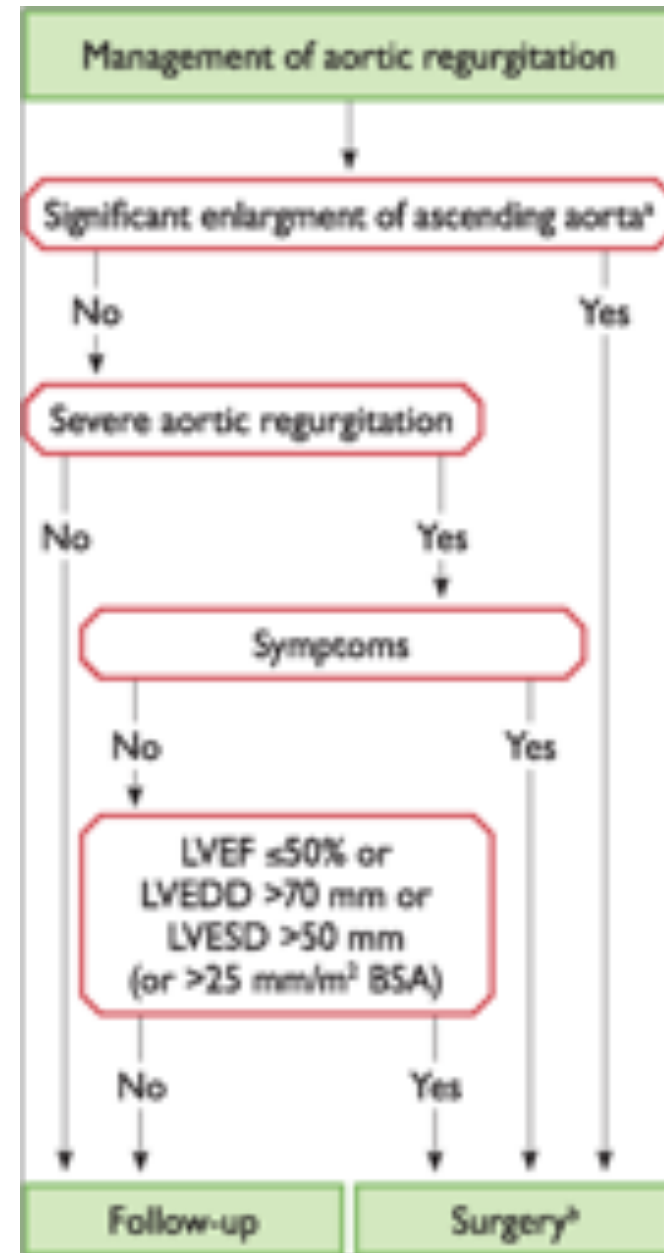
Surgery might be reasonable in case of increase greater than 20 mm Hg



PH en de guideline Aol

Invloed RVF/PH op besluitvorming bij Aol

1. PH is een marker voor verminderde functionele capaciteit, en dus een additioneel argument voor AVR



PH en de guideline AoS

Invloed RVF/PH op besluitvorming bij AoS

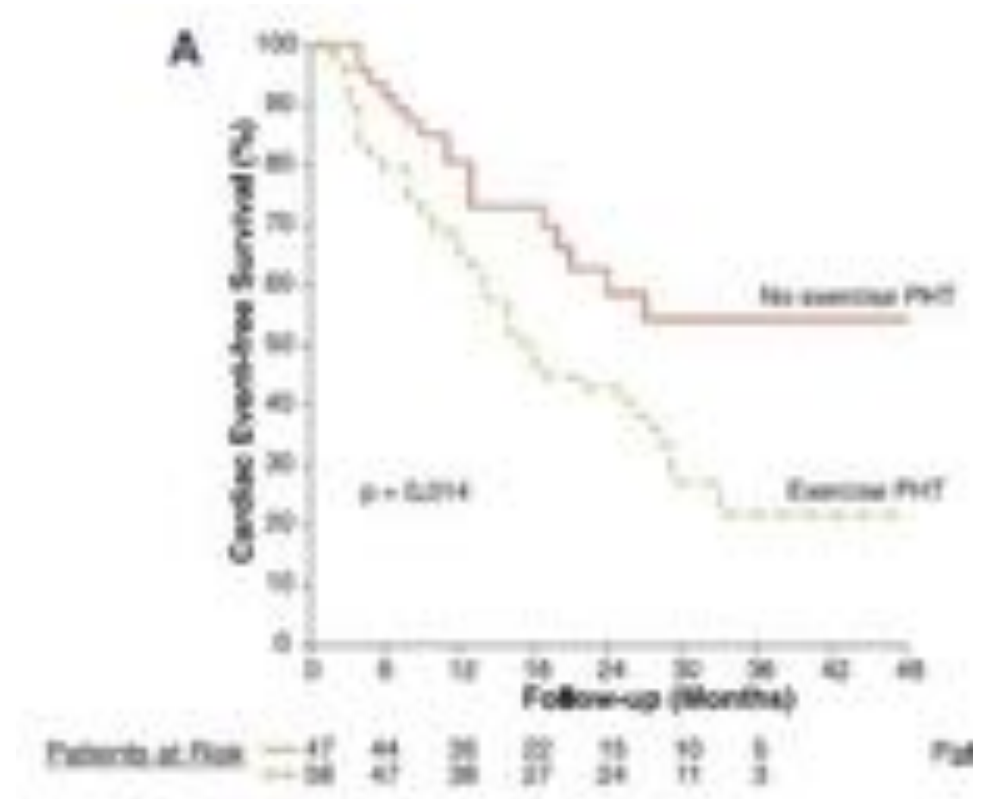
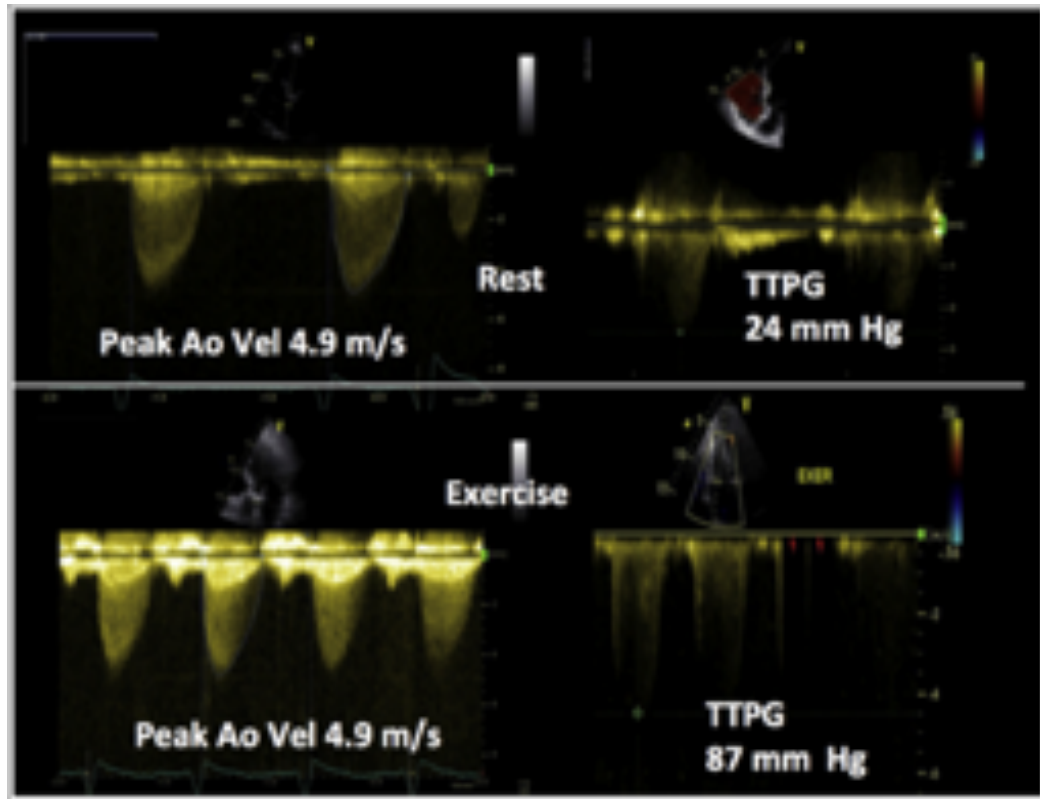
1. Bij asymptomatische ernstige AoS met behouden LVF is PH een indicatie voor AVR

Surgery should be considered (IIa C) if one of the following is present:

- ✓ Peak velocity >5.5 m/s
- ✓ Severe valve calcification + V1max progression ≥ 0.3 m/s per year
- ✓ Markedly elevated neurohormones (>3xULN)
- ✓ Severe pulmonary hypertension (SPAP>60 mmHg)

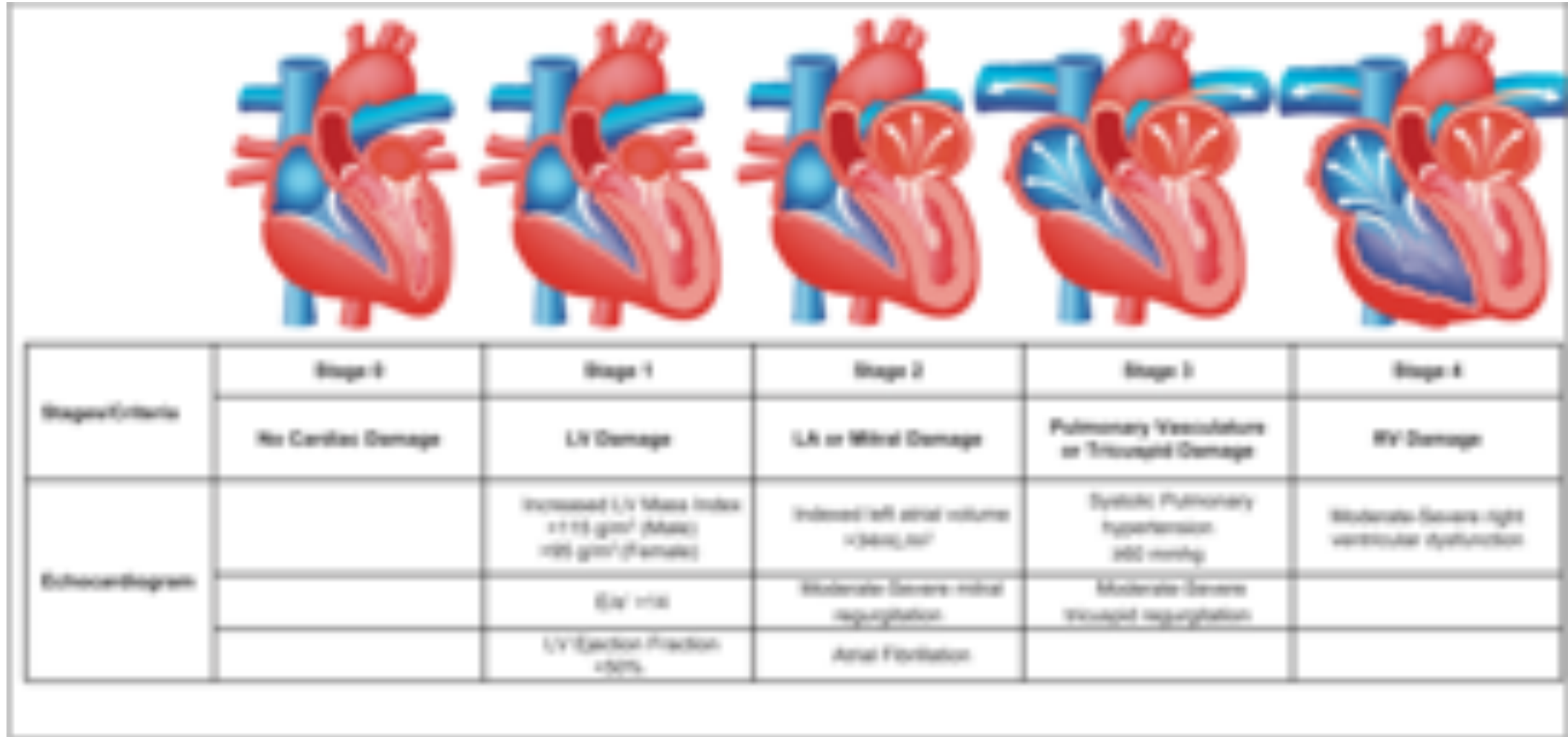


AoS en inspannings PH



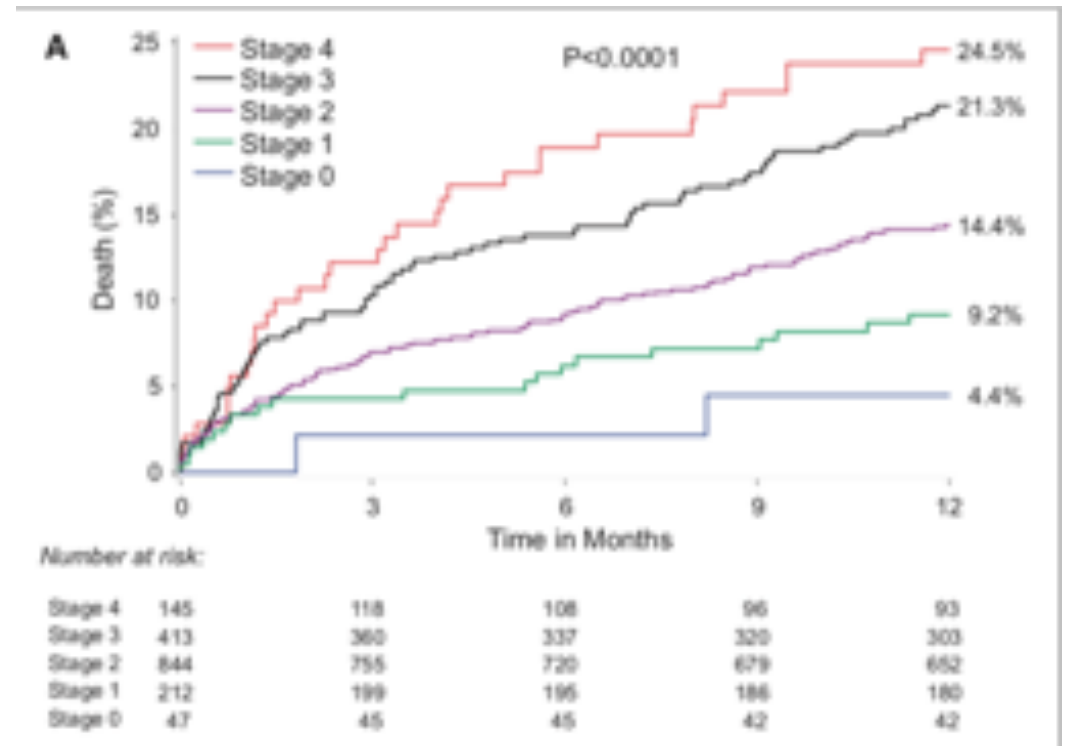
Surgery might be reasonable in case of increase greater than 20 mm Hg

Stagering van kleplijden obv cardiale schade

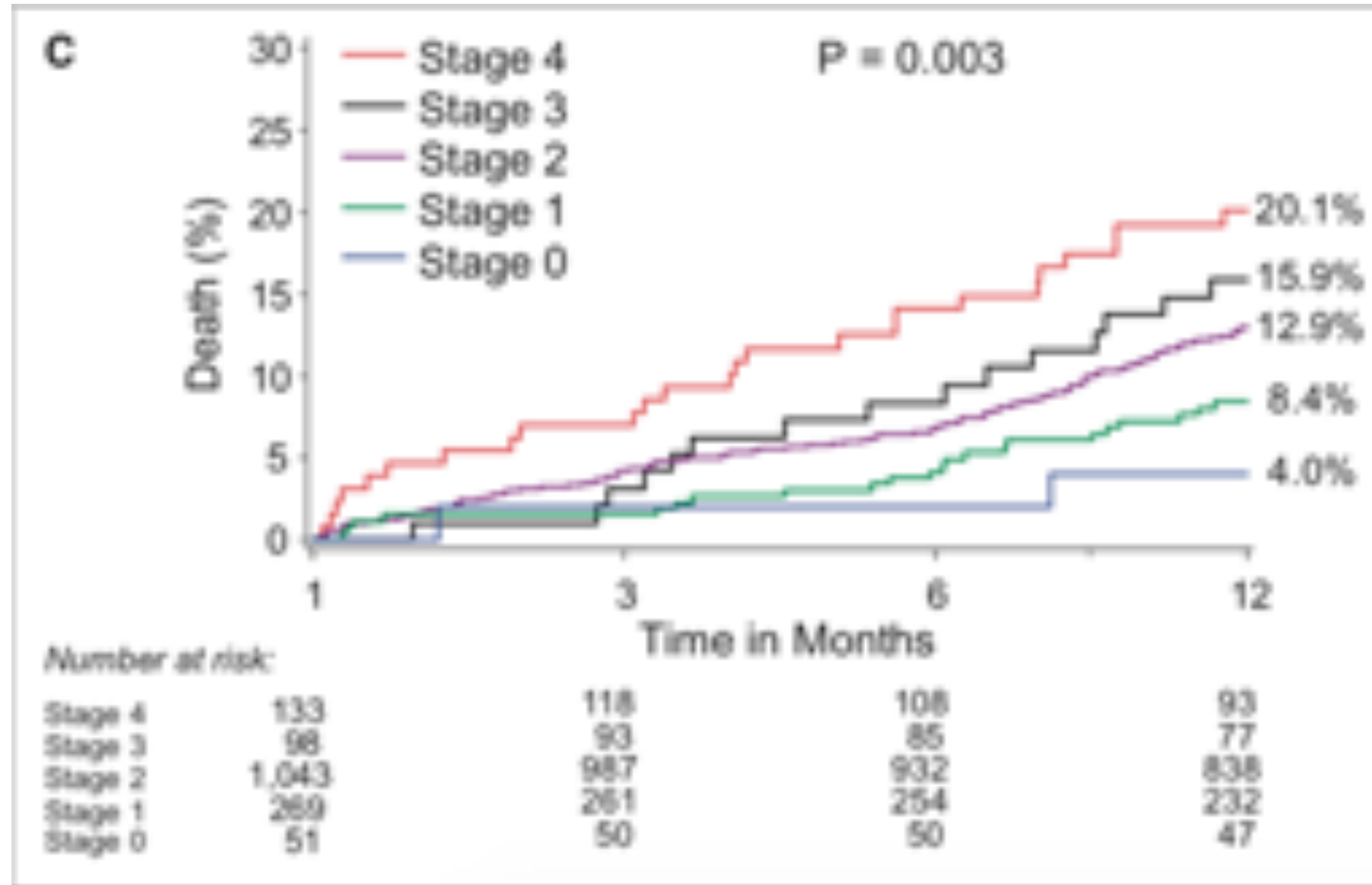


Impact of cardiac damage on survival in AoS

Stages of cardiac damage	
Stage 0 (no cardiac damage)	47/1661 (2.8%)
Stage 1 (left ventricular damage)	212/1661 (12.8%)
Stage 2 (left atrial or mitral valve damage)	844/1661 (50.8%)
Stage 3 (pulmonary vasculature or tricuspid valve damage)	413/1661 (24.9%)
Stage 4 (right ventricular damage)	145/1661 (8.7%)



Mortaliteit na AVR (landmark analysis)



Predictors of mortality

Table 3 One-year predictors of mortality among patients with severe aortic stenosis undergoing aortic valve replacement

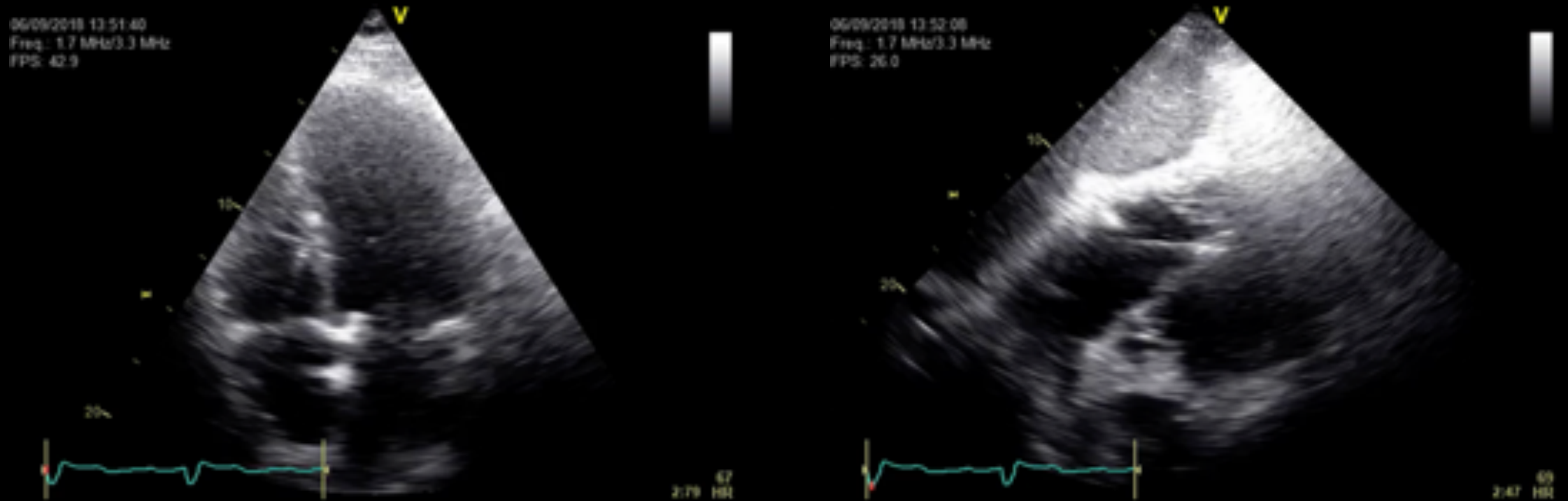
Variables	Unadjusted hazard ratio (95% confidence interval)	P-value	Adjusted hazard ratio (95% confidence interval)	P-value
Model 1				
Stage of cardiac damage (by each stage increase)	1.46 (1.27–1.67)	<0.0001	1.41 (1.20–1.66)	<0.0001
Society of Thoracic Surgeons score (by each TS increase)	1.05 (1.02–1.08)	0.0002	1.03 (0.99–1.07)	0.10
F frailty	1.98 (1.48–2.64)	<0.0001	1.83 (1.35–2.49)	<0.0001
Age (by each 10 years increase)	1.13 (0.95–1.35)	0.17	1.13 (0.89–1.43)	0.32
Male sex	1.14 (0.89–1.47)	0.28	1.25 (0.92–1.70)	0.15
O ₂ -chronic obstructive pulmonary disease	1.90 (1.31–2.76)	<0.0001	1.99 (1.24–3.17)	0.004
Renal insufficiency	1.37 (0.90–2.08)	0.14	0.79 (0.46–1.35)	0.39
Coronary artery disease	0.89 (0.69–1.15)	0.37	0.95 (0.69–1.29)	0.73
Previous coronary artery bypass graft	0.91 (0.68–1.22)	0.55	0.95 (0.65–1.37)	0.77
V _{max} (by 0.5 m/s increase)	0.91 (0.82–1.01)	0.074	0.91 (0.80–1.04)	0.17
Aortic valve area index (by 0.1 cm ² decrease)	0.96 (0.84–1.10)	0.53	0.99 (0.84–1.16)	0.88

Impact of cardiac damage on AVR indication

Aortic Stenosis Grading and Staging Classification

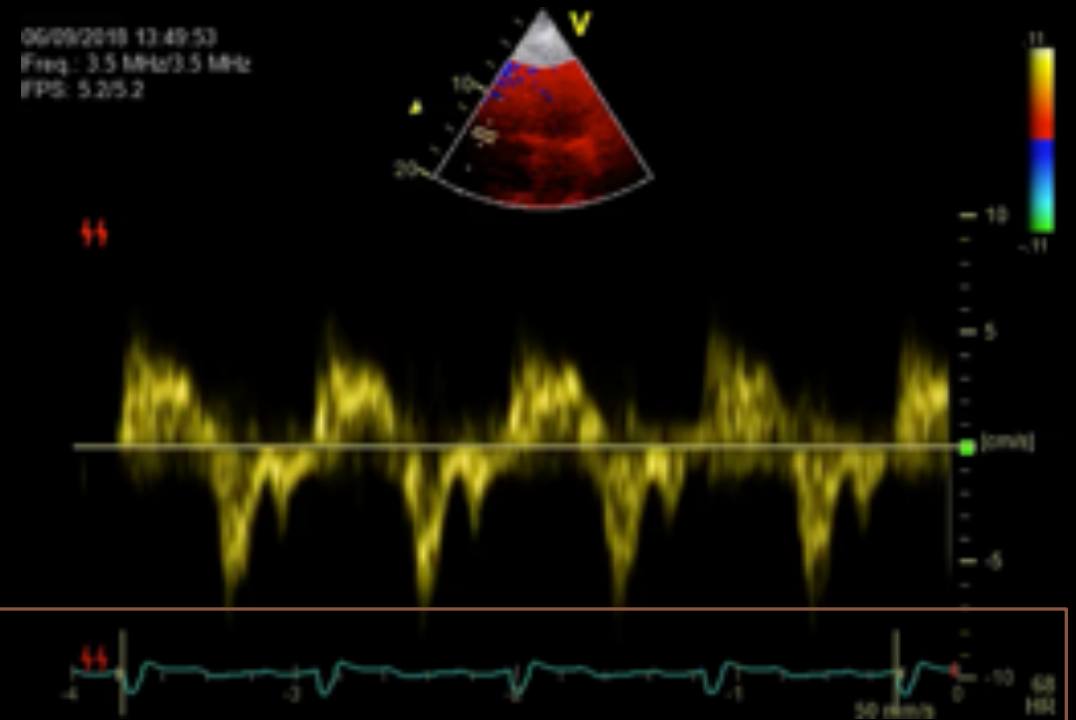
Grade/Stage	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
	No cardiac damage	LV damage	LA, Mitral damage	PA, Tricuspid damage	RV damage
Grade 0 <small>(V_{max} <2 m/s)</small>	Class III				
Grade 1 <small>(V_{max} 2.0-2.9 m/s, MG <20 mm Hg)</small>					
Grade 2 <small>(V_{max} 3.0-3.9 m/s, MG 20-39 mm Hg)</small>	Class IIa or IIb				
Grade 3 <small>(peak jet velocity ≥ 4.0 m/s or MG ≥ 40 mm Hg, V_{max} ≥ 4.0 m/s, MG ≥ 40 mm Hg)</small>					

Myocardiale dysfunctie post CABG/post OHO



- ✓ Tijdens en na cardiale chirurgie ontstaat er een achteruitgang in RV performance.
- ✓ Herstel is niet altijd volledig en echocardiografische dysfunctie kan tot 1 jaar na de operatie perisisteren

Myocardiale dysfunctie post CABG/post OHO

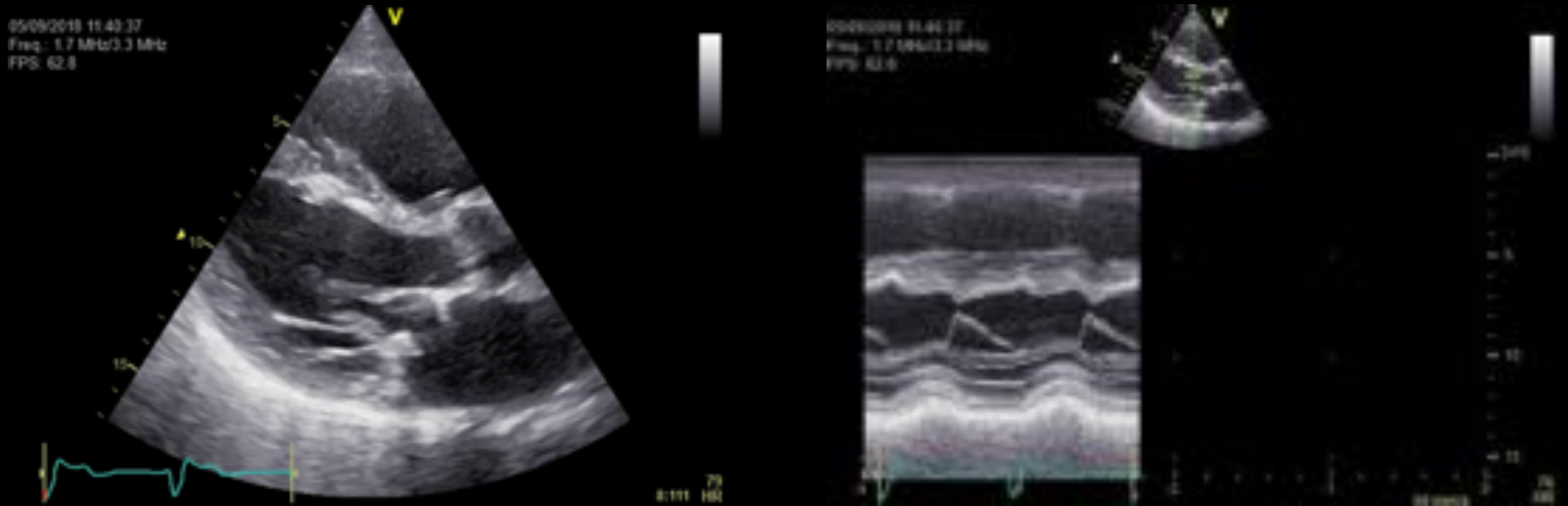


De oorzaak is niet duidelijk:

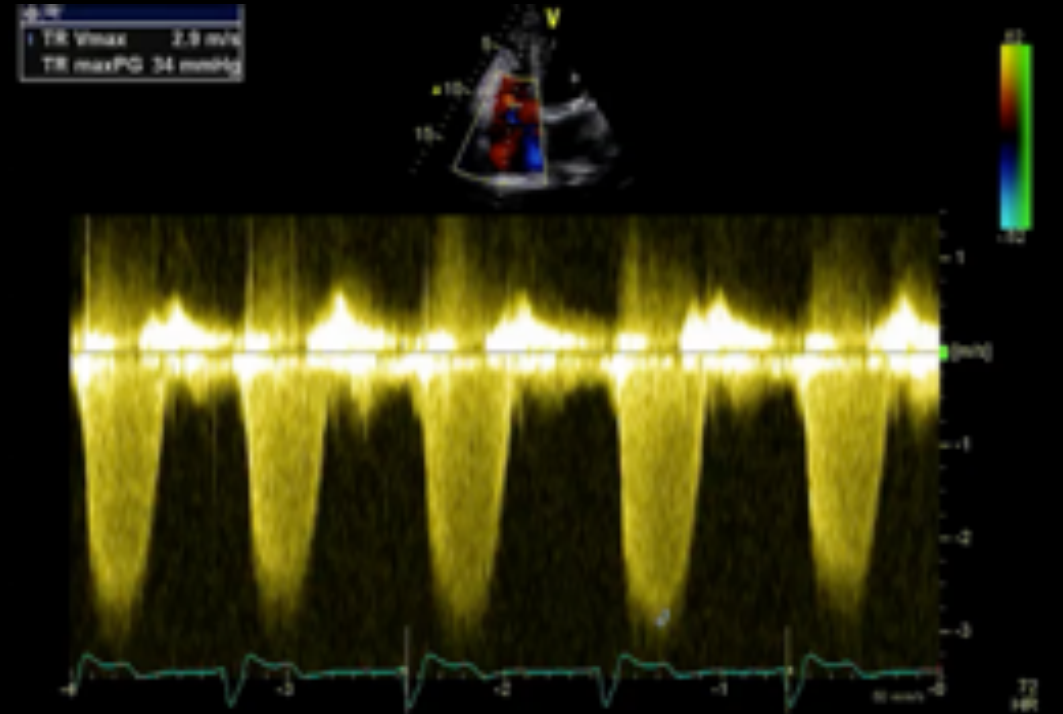
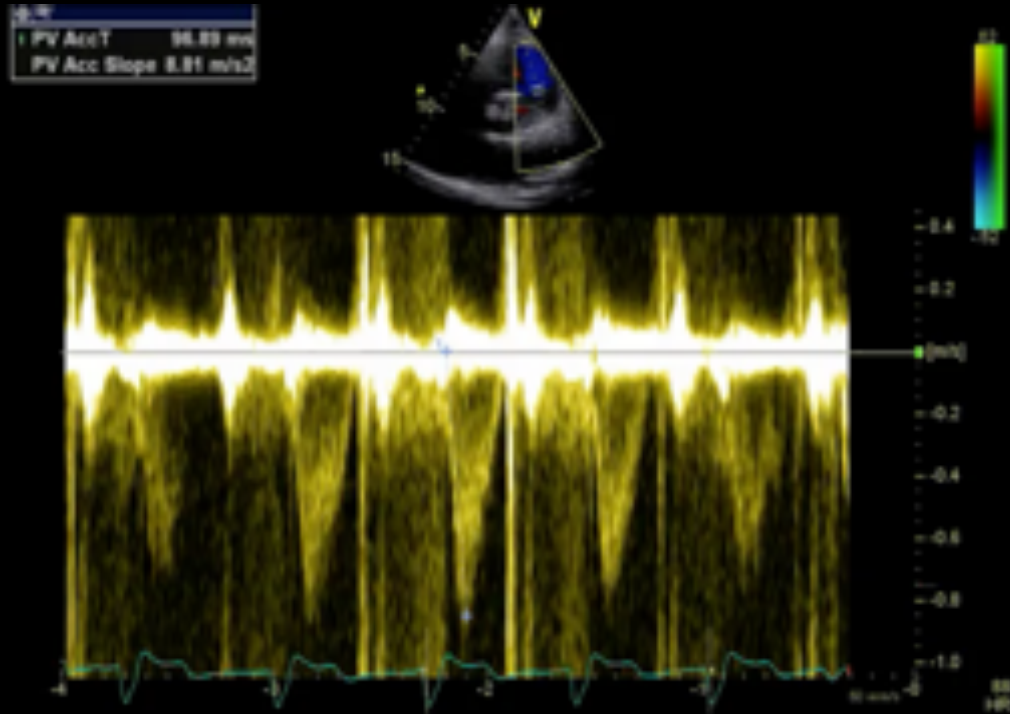
- 1) myocardiale hypothermie
- 2) cardiopulmonary bypass
- 3) pericard adhesie

Minimaal invasieve mitralisklep plastiek met laterale pericard opening vermindert postoperatieve RV dysfunctie

Paradoxale septum beweging post MVP



Aanwijzing voor Rest-PH...



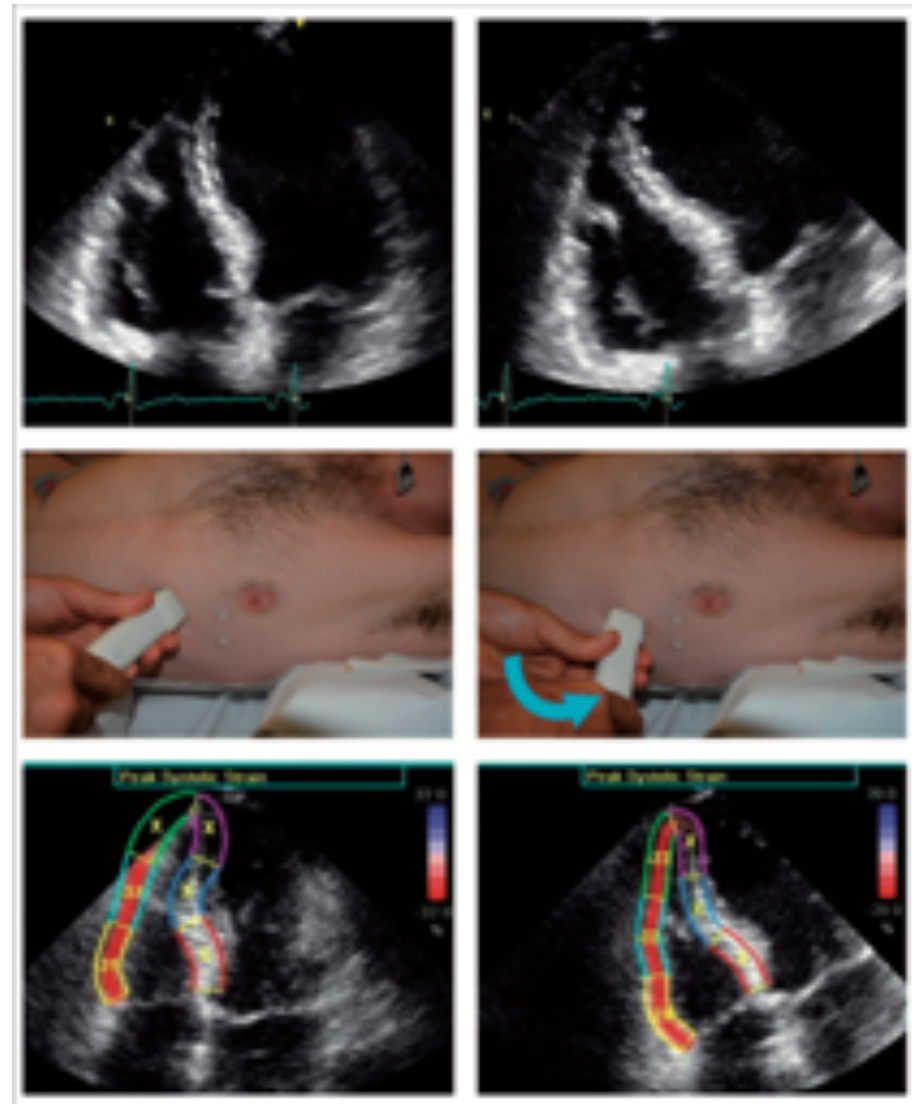
Prevalentie en impact op prognose en beleid

	Clinical Status	Rest (sPAP >50 mm Hg)			Exercise (sPAP >60 mm Hg)		
		Prevalence	Outcome Impact	Guidelines for Surgery	Prevalence	Outcome Impact	Guidelines for Surgery
Aortic stenosis	Symptomatic	15%–30%	≈2-fold increase of 1-y mortality after intervention	—	—	—	—
	Asymptomatic	6%	<ul style="list-style-type: none"> • Resting PH not associated with reduced survival • Significant relationship between resting SPAP and outcome exists 	IIa (ESC)	55%	≈2-fold increase risk of cardiac event	—
Aortic regurgitation	Asymptomatic for long	16%–24%	Increased risk of events	—	—	—	—
Mitral stenosis	Asymptomatic for long	14%–33%	3-fold increased risk of death at 10 y	IIa (ESC)	>30%	—	—
Primary MR	Symptomatic	20%–30%	>2-fold increase in risk of postoperative death	—	—	—	—
	Asymptomatic	6%–30%	2-fold increase in risk of occurrence of symptoms	IIa (ESC; AHA/ACC)	≈50%	>3-fold increase in risk of occurrence of symptoms	—
Secondary MR	Symptomatic for most	37%–62%	≈1.4-fold increase in risk of death	—	40%	>5-fold increase in risk of death, involved in the pathogenesis of acute pulmonary edema	—

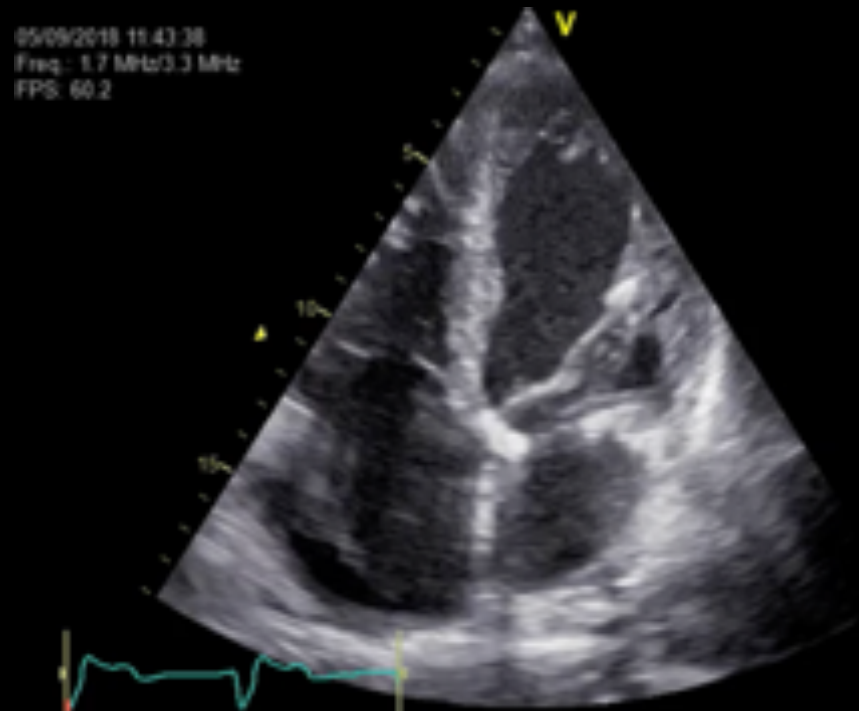
2D strain metingen van de RV

prognose bepaling bij

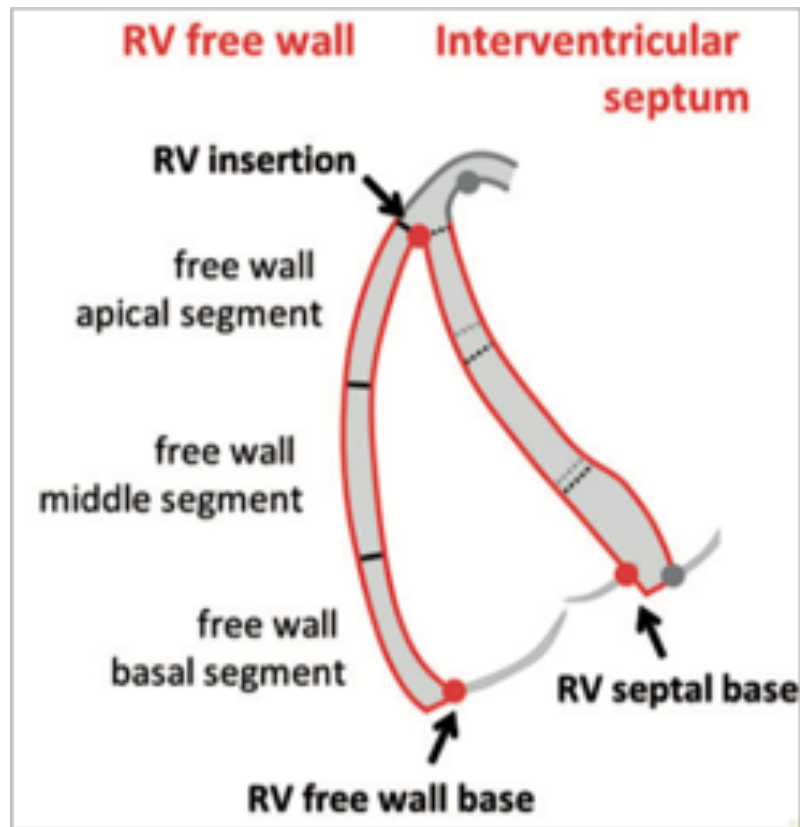
- ✓ Pulmonary arterial hypertension
- ✓ Pulmonary embolism
- ✓ Acute coronary syndromes
- ✓ Left ventricular failure
- ✓ Arrhythmogenic cardiomyopathy
- ✓ Congenital heart diseases



RV in beeld



2D strain bepaling van de RV



- RV-focused apical four-chamber view
- Definitie ROI (cave pericard): 5mm
- Trace vanaf de laterale- naar de mediale tricuspidalis annulus
- Voorkeur heeft de RV vrije wand
- Longitudinal strain
- Peak systolic values

Conclusies

RV dysfunctie en PH:

- Zijn frequent het gevolg van VHD
- Gaan gepaard met een verminderde prognose

RV dysfunctie en PH kan worden gezien als end-stage cardiale schade bij VHD (stage 4)

Behandeling van de klep mitigeert het verhoogde risico niet

De GL zijn inconsequent door het waarderen van RVD en PH, als klasse 2 indicatie (*should be considered*)

Nieuwe RV meetmethodes zoals 2D strain en inspanningsecho moeten de risico stratificatie en timing van klep-interventie verbeteren



Perfect
timing...
