Vše, co potřebuji vědět o chlopenních vadách ke kardiologické atestaci

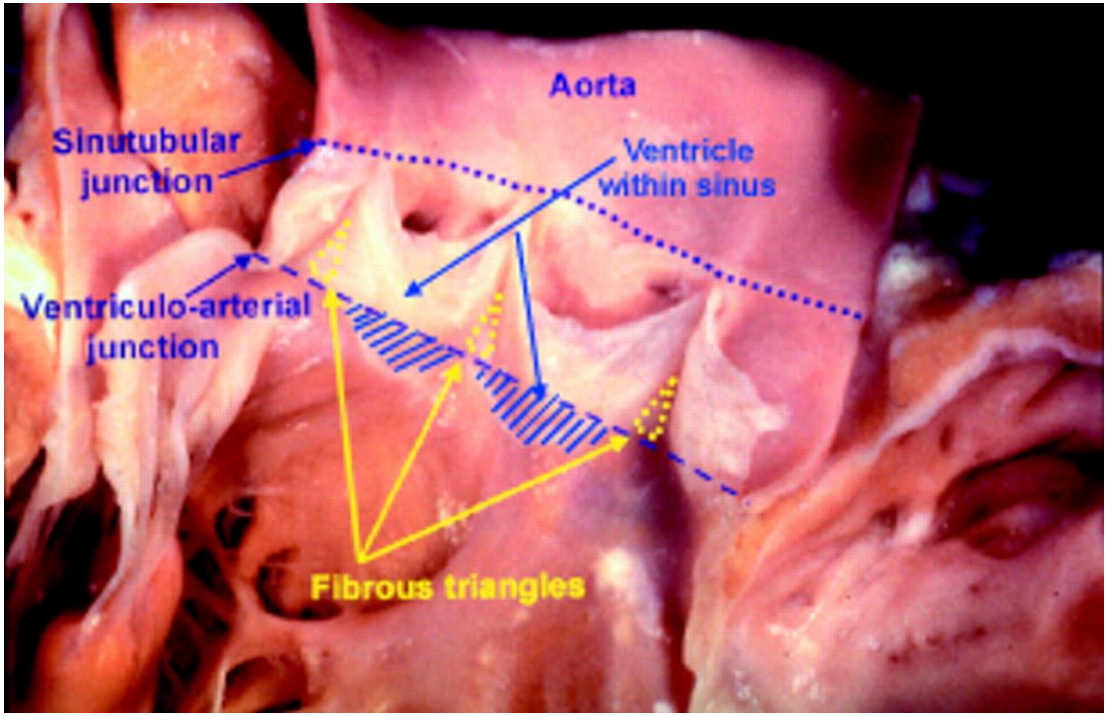
Aortální regurgitace

Etiologie a diagnostické metody

Radka Kočková

Anatomie aortální chlopně

The aortic root has been opened through a longitudinal incision across the area of aortic-mitral valvar continuity, and spread open to show the semilunar attachments of the valvar leaflets.

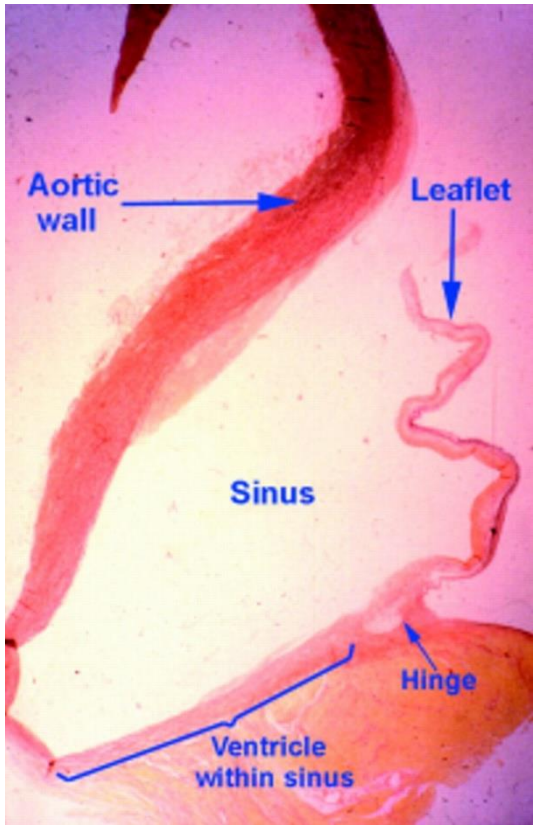


Robert H Anderson Heart 2000;84:670-673

Heart

Anatomie aortální chlopně

This section across one of the two coronary sinuses of the aortic valve shows how the hinge of the valvar leaflet is attached to the ventricular myocardium well proximal to the anatomic ventriculo-arterial junction (see fig 5 also).

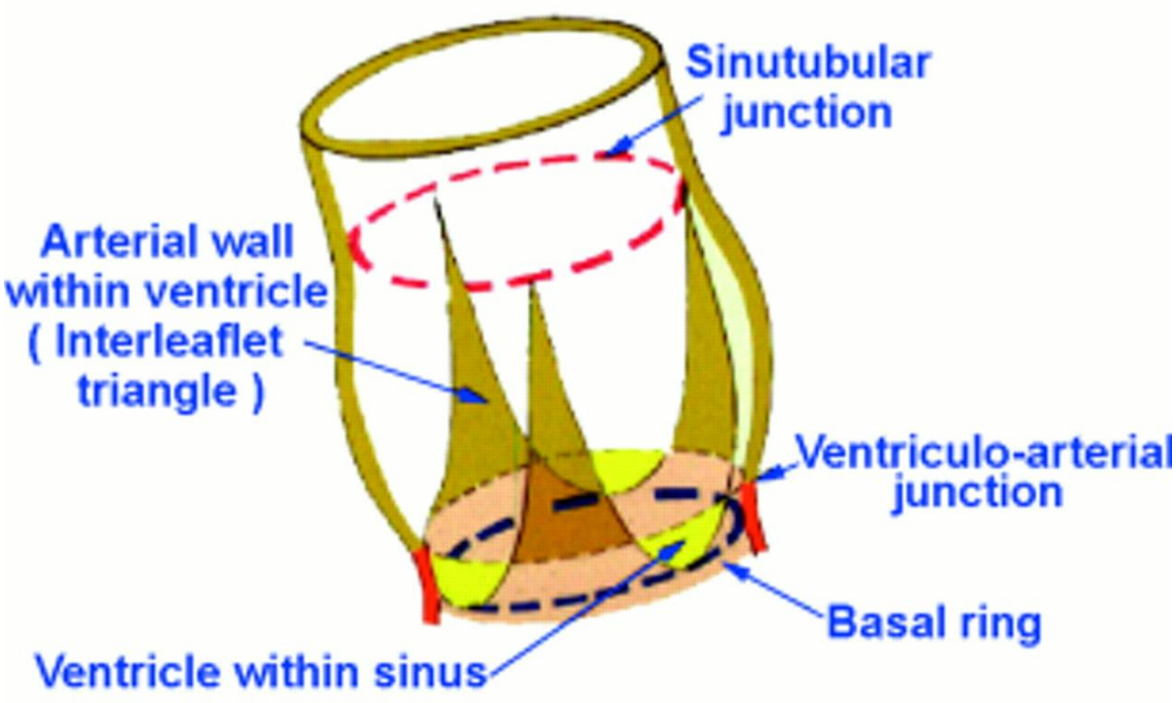


Robert H Anderson Heart 2000;84:670-673

Heart

Anatomie aortální chlopně

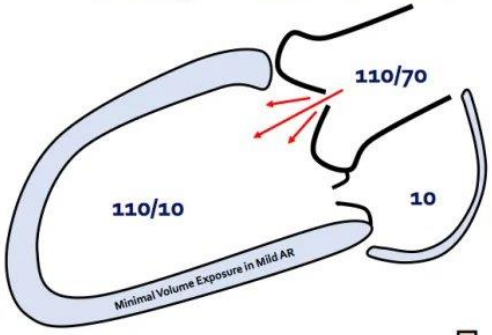
A diagrammatic representation of the aortic root shows its considerable length.



Robert H Anderson Heart 2000;84:670-673

PATHOPHYSIOLOGY OF AORTIC REGURGITATION

Early Mild Aortic Regurgitation

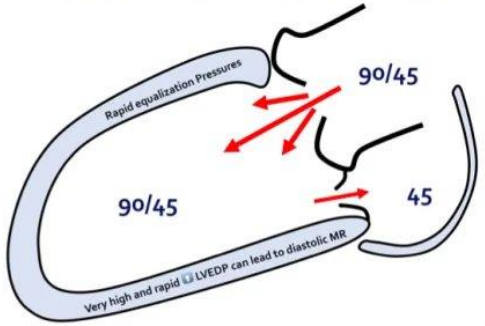


Aortic Regurgitation can lead to LV Volume Overload (⬆ LVEDV)...

...And LV Pressure Overload (as ⬆ LVEDV leads to Systolic Aortic HTN)

But if only Mild AR: not exposed to significant Regurgitant Volume and patients are generally asymptomatic

Acute Severe Aortic Regurgitation



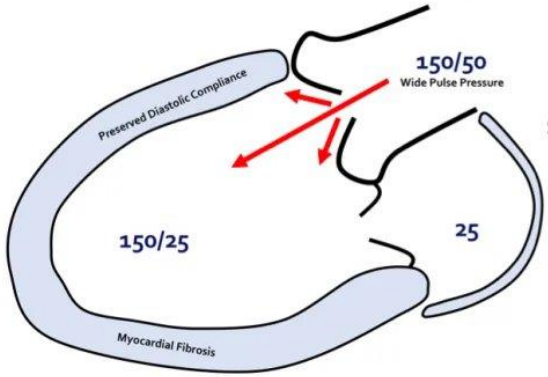
Acute Aortic Regurgitation → sudden and severe clinical deterioration

The LV: ⛔ time to compensate for rapid ⬆ LV volume

Cardiac Output decreases rapidly → Cardiogenic Shock

⬆⬆ LVEDP and LV decompensation can lead to *diastolic* MR → Pulmonary Edema

Chronic Severe Aortic Regurgitation



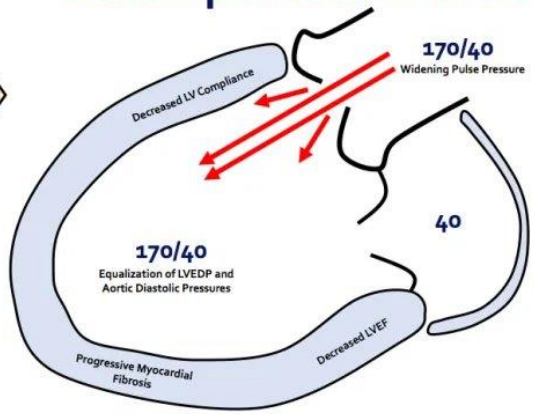
⬆ LVEDV leads to ⬆ LV Wall Stress [LaPlace Law ~ (Pressure * Radius)/(2 * Thickness)]

So to compensate, there is LV remodeling with eccentric hypertrophy

This helps maintain LV compliance and LV Volume/Mass Ratio

LVEF Preserved in this Stage

Decompensated Aortic Regurgitation



Over time: ⬆ LV Volume Overload, ⬆ Myocardial Fibrosis, and ⬇ LV Compliance

This will lead to LV Dilation, ⬇ LVEF and a chronic decompensated state

More likely to see CHF symptoms and exertional dyspnea at this stage

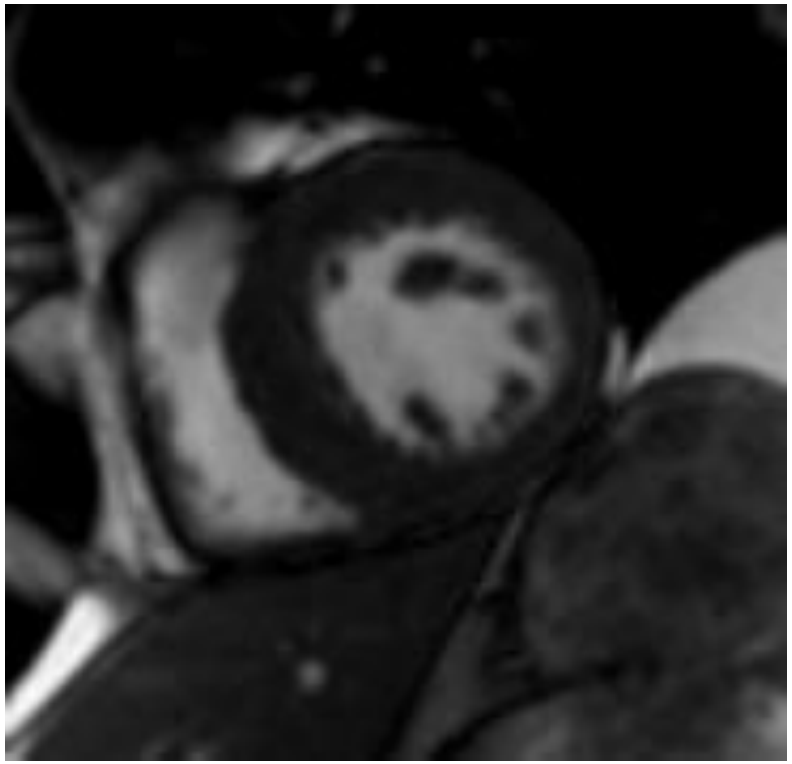
Produced by @EvelynSong | @karanpdesai

#CNCR
www.cardionerds.com

Chronická aortální regurgitace

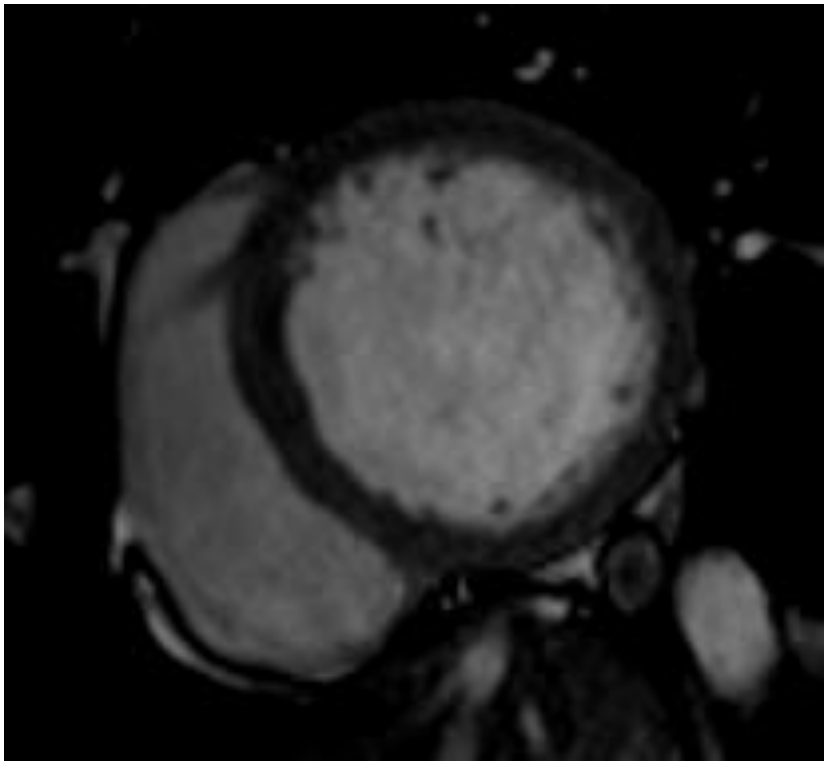
Významná AR – remodelace LK

- EF 58%, EDVi 106 ml/m^2
- IVS 18-22 mm



EF 59%, EDVi 215 ml/m^2

IVS 10 mm

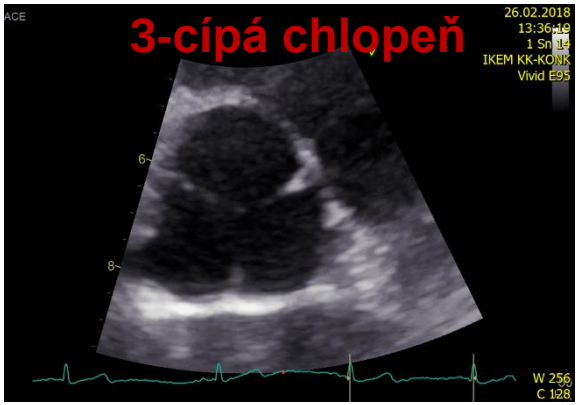


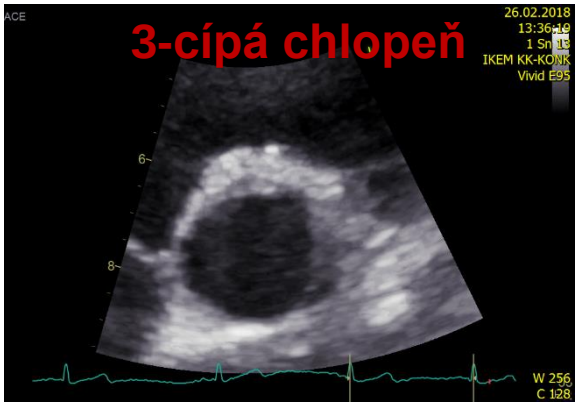
Etiologie aortální regurgitace

Postižení cípů

- ***Vrozené*** **– bikuspidální**
  unikuspidální
  kvadrikuspidální
  defekt septa komor
- ***Získané*** **– kalcifikace**
  IE
  postiradiační
  porevmatické
  toxicita (anorektika, karcinoid)
  trauma

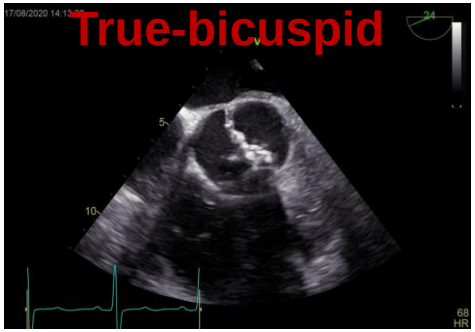
Etiologie aortální regurgitace



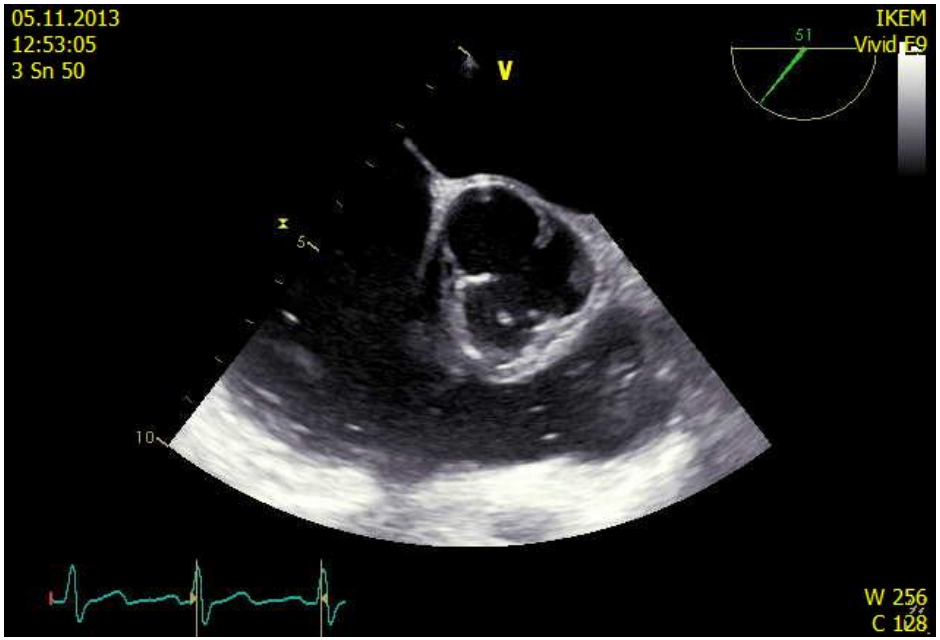


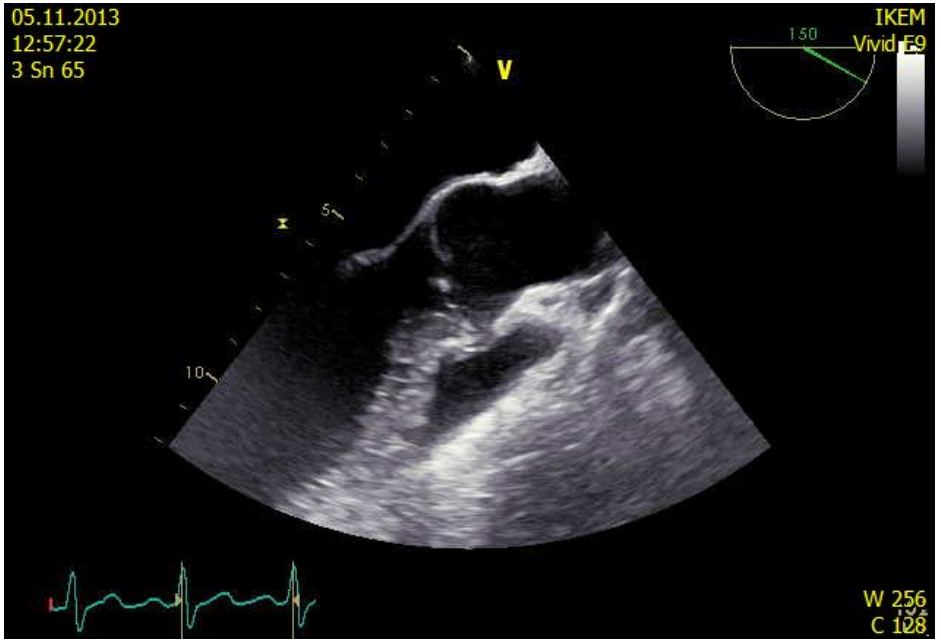
Normální průtok
Laminární tok

Abnormální průtok
Turbulence, gradient



ECHO – RCC+LCC

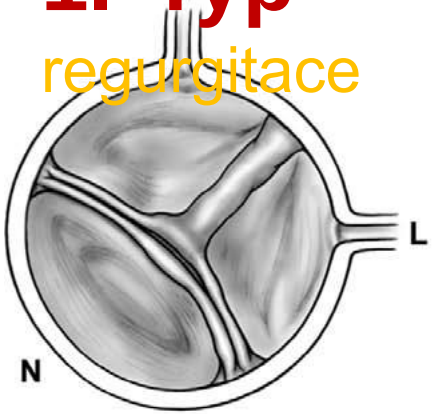




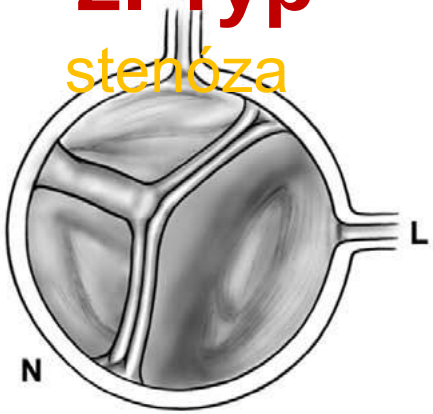
Velmi tenké cípy a prolaps způsobující regurgitaci

Typy BAV

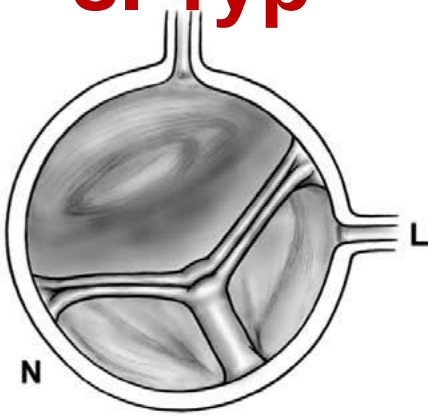
1. Typ
regurgitace



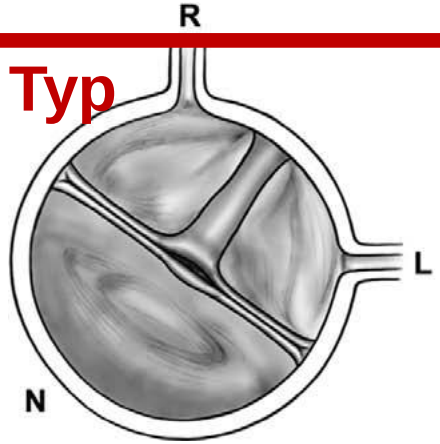
2. Typ
stenóza

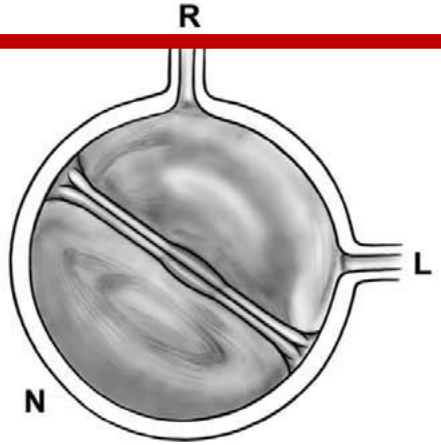


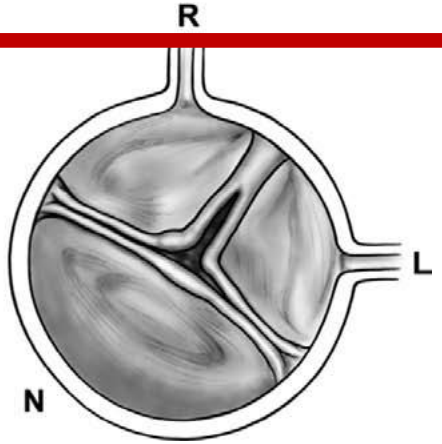
3. Typ



1. Typ





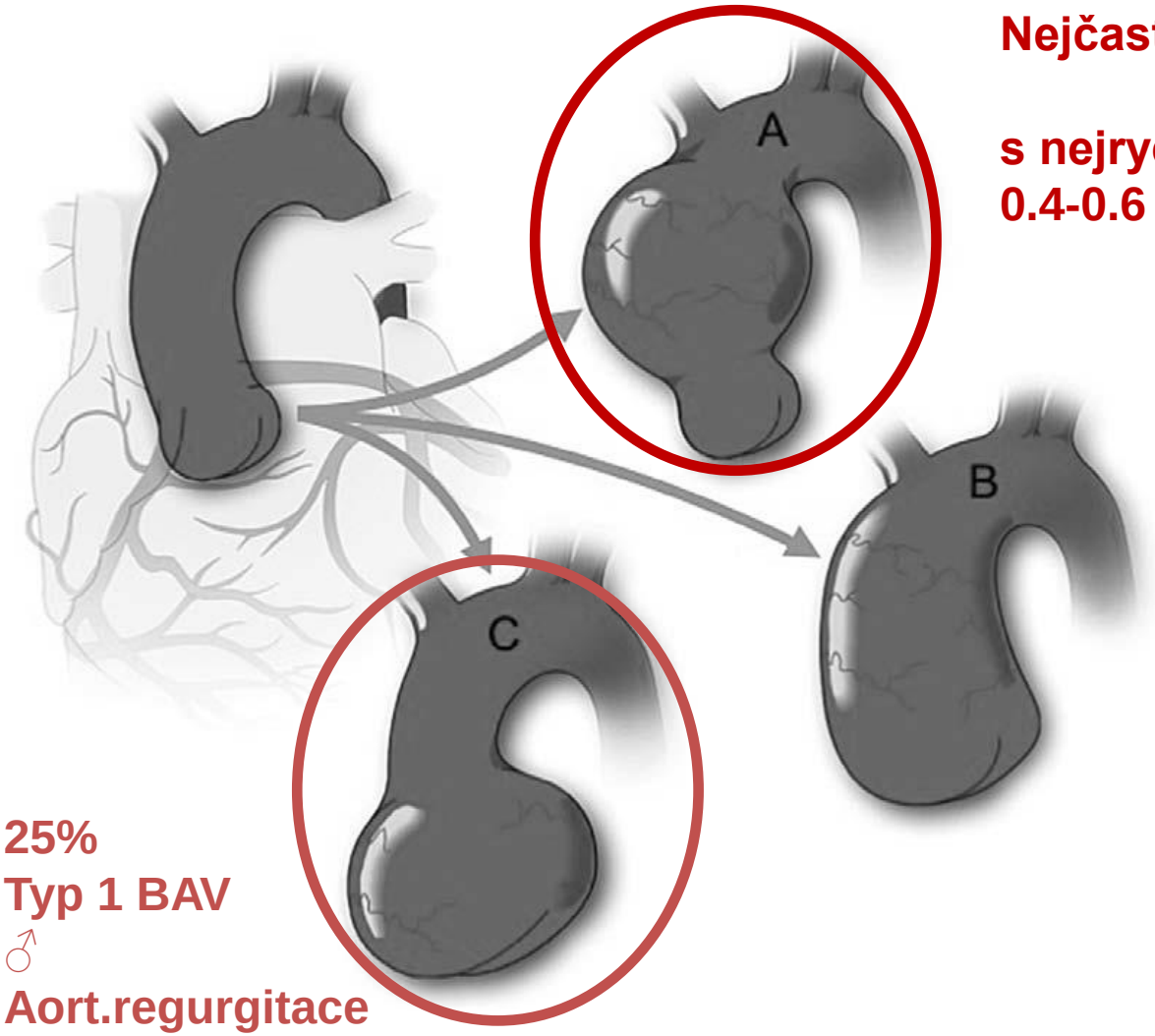


Michelena H. Circulation 2014

True bicupsid

- **Jen 5 % BAV je tvořeno 2 cípy, které zaobírají každý 180º, jsou zcela symetrické a pak jsou i sinusy Valsalva jen dva**

Druhy aortopatie u BAV



Nejčastější typ 60-80%

s nejrychlejší progresí
0.4-0.6 mm/rok

25%
Typ 1 BAV
♂
Aort.regurgitace

Michelena H. Circulation 2014

Podobnost BAV a Marfanova syndromu

- **Progresívní dilatace aorty u 20-84% pacientů s BAV**
- **riziko disekce je 8x větší než v běžné populaci (50% pacientů s BAV - ↓↓elastických vláken s tunica media,**
- ***Marfanův sy – 100% má strukturální změny v tunica media aorty***

- **Aortální disekce u jedinců mladších 40-ti let**
  - **50% Marfan sy *(prevalence 5-10:10 000)***
  - **9% BAV *(prevalence 1-2%)***

BAV – klinický přístup

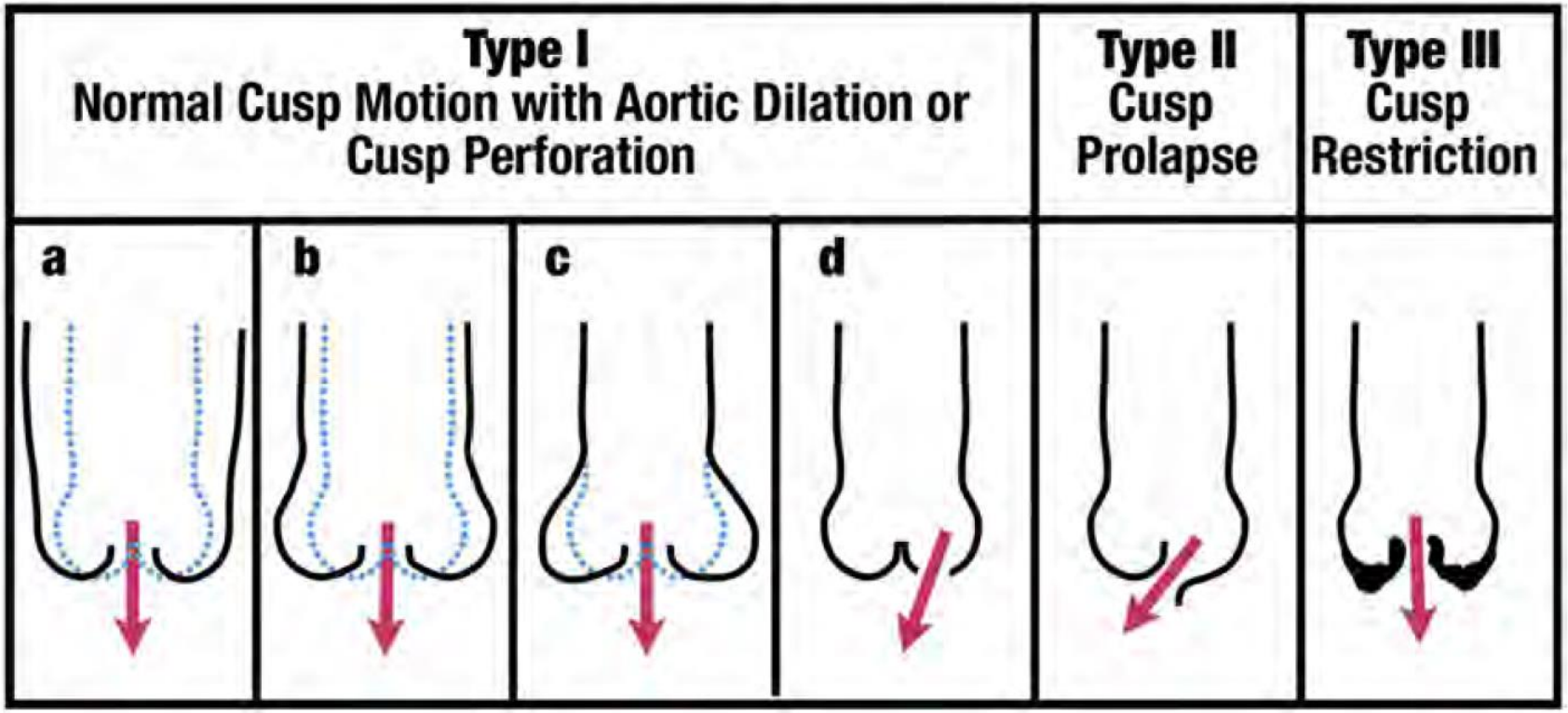
- Rodinný screening (5-10% prvostupňových příbuzných postiženo, pozor – 3 cípy a izolovaná dilatace asc.aorty)
- Nutno vyloučit koarktaci aorty
- Pravidelné ECHO kontroly dle aktuálního nálezu (6M – 5 let)
- Řádná zubní hygiena – prevence IE
- Aorta ≥ 40 mm – MRI či CT (6-12 měsíců kontrola)
- přísná kontrola krevního tlaku (beta-blokátory) – cíl 120/80 mmHg
- Preventivní náhrada aorty při rozměru ≥ 50 mm + ≥ 1 rizik.faktor *(koarktace, art.hypertenze, pl.těhotenství, RA disekce, významná AR, MR)*, jinak při ≥ 55 mm

Etiologie aortální regurgitace

Onemocnění kořene aorty

- *Vrozené* – anuloaortální ektazie
  onemocnění pojivové tkáně
  (Loeys Dietz, Ehlers-Danlos, Marfan sy)
- *Získané* – idiopatická dilatace kořene
  art.hypertenze
  autoimunitní onemocnění
  (systémový lupus, m.Bechtěrev, Reiter sy)
  Aortitis (syfilitická, Takayasu arteritis)
  Trauma

Klasifikace AR podle morfologie



2017 ASE Guidelines

Symptomy

- Asi 1/3 pacientů podstupujících operaci pro významnou AR je asymptomatická
- Mladší pacienti – neurčité stesky typu snížené výkonnosti, větší únavnosti
- Typickou dušnost - relativně méně pacientů
- Pocit tepu v hlavě či šelestu v uších

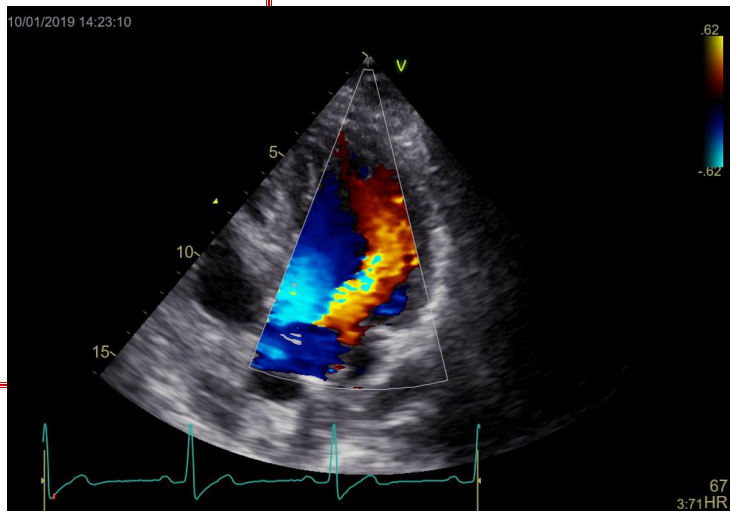
Klinické vyšetření

- EKG obvykle bez pozoruhodností či známky hypertrofie LK u pokročilé vady
- Poslechově – holodiastolický dekrescendo šelest s maximem v Erbově bodě, může být diast.šelest Austina-Flinta
- Silné pulzace – Corriganův tep, Mussetův příznak, Quincke.pulzace
- TK – častěji art.hypertenze (hypercirkulační), rozdíl mezi STK a DTK (např. 140/40 mmHg)

Kvantifikace AR - barevný doppler

Doporučení EACVI 2010

- Barevný doppler slouží především k diagnostice vady
- Plocha regurgitačního jetu v barevném doppleru by neměla být užívána ke kvantifikaci regurgitace
- Komplexní kvantifikace vady –
  > malá regurgitace



Slabiny barevného doppleru u AR

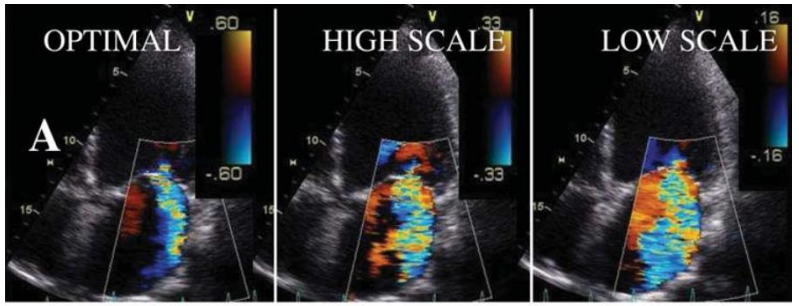
Nejčastěji používané
Nejméně spolehlivé ! ! !

Tlakový gradient TK
Objem protékající krve
Délka diastoly TF
Excentrické jety

Nastavení

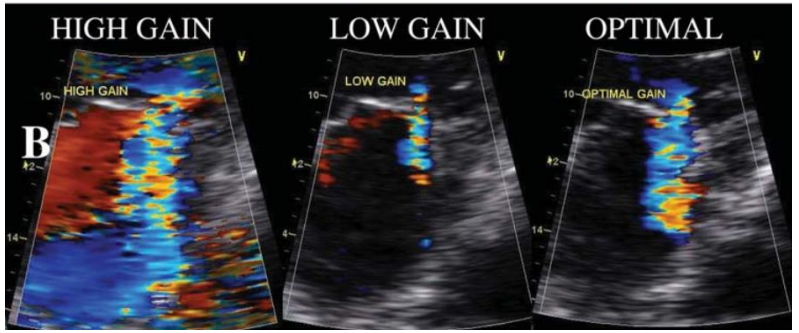
Scale

50-60 cm/s



Gain

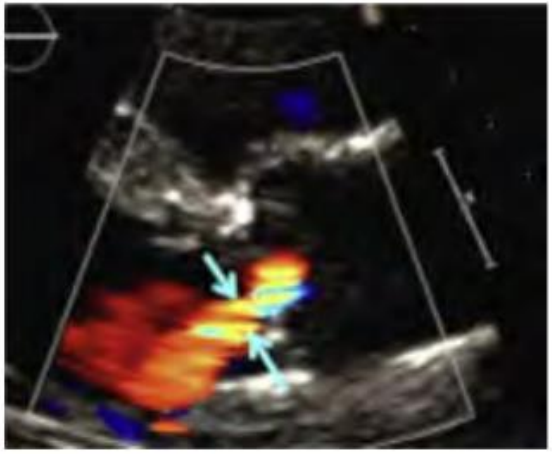
-1 od artefaktů



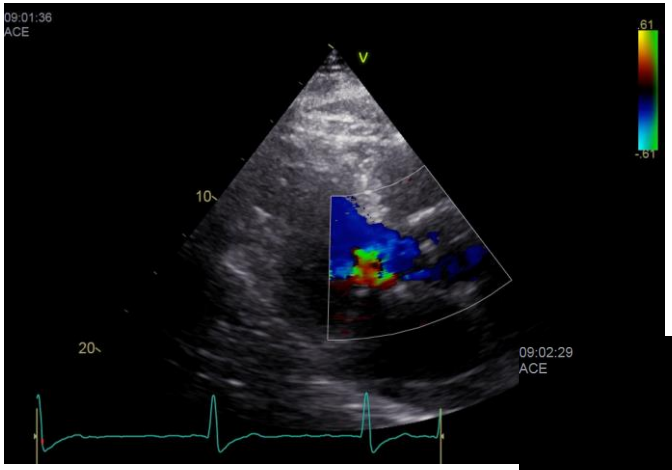
Příliš spoléháme na barevný doppler ?

Nutno optimalizovat, pozor na TK a TF!!!

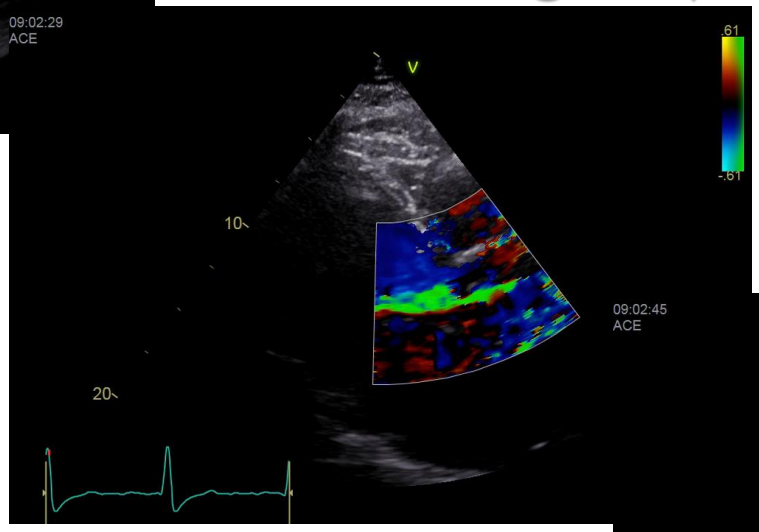
- **Optimalizace depth – ↑ frame rate**
- **Malý sektor barevného doppleru ↑ frame rate**
- **ZOOM pro měření**
- **EKG – vhodný cine-loop**
- **Minimálně 2 projekce**



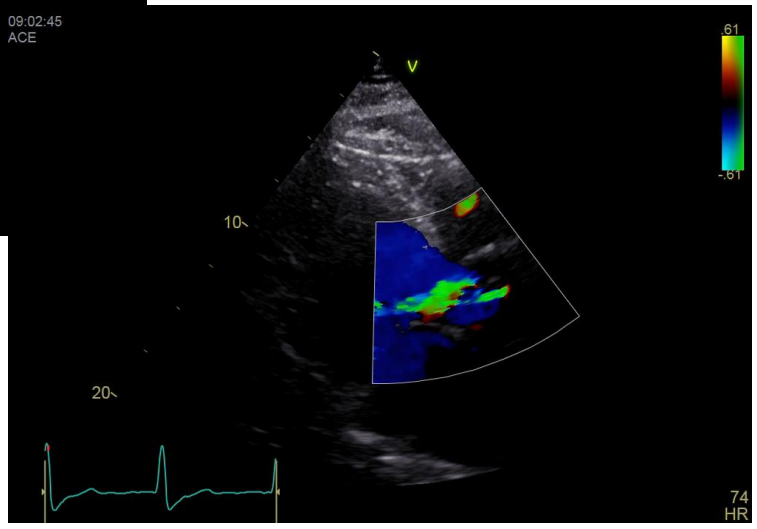
Barevný doppler - optimalizace



ZOOM+2D gain ↓

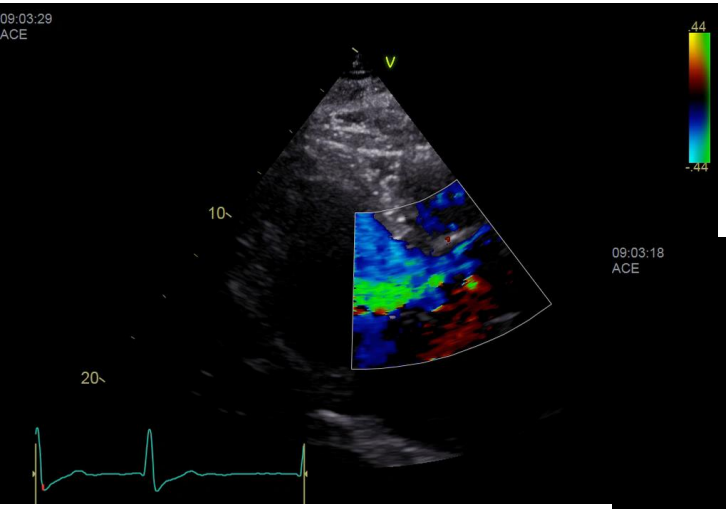


Gain doppleru ↓ ↓

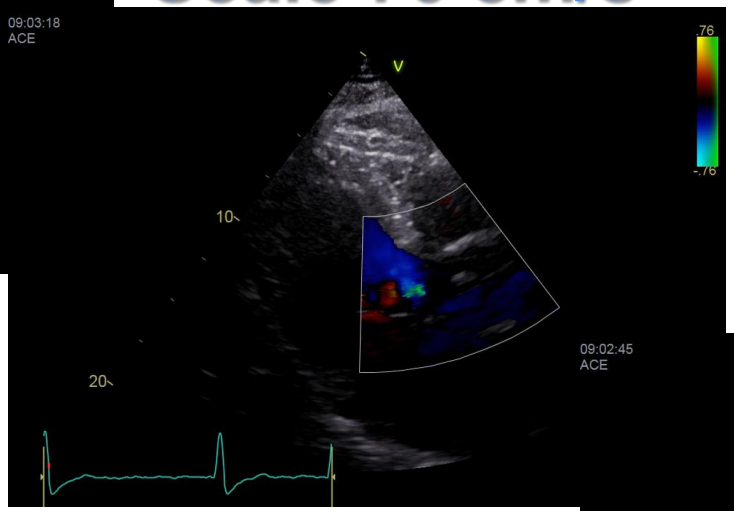


Barevný doppler - optimalizace

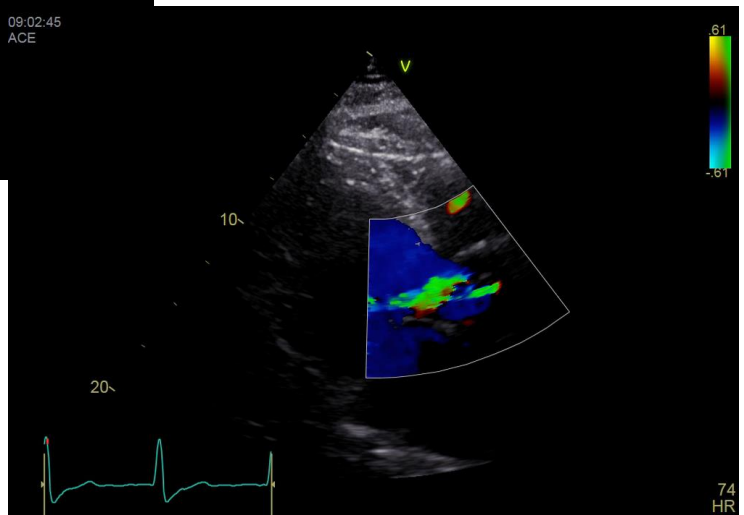
Scale 44 cm/s



Scale 76 cm/s

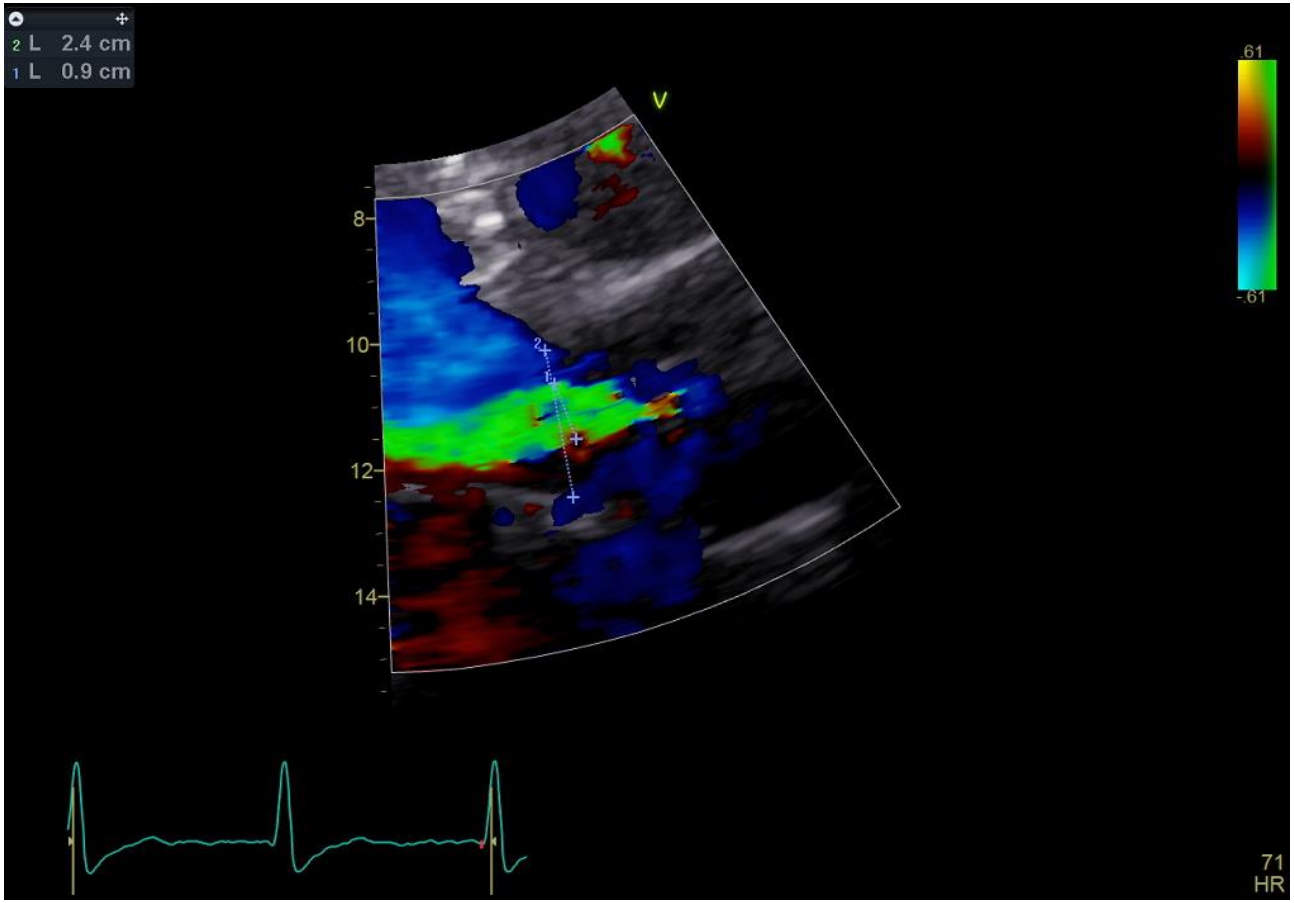


Scale 61 cm/s



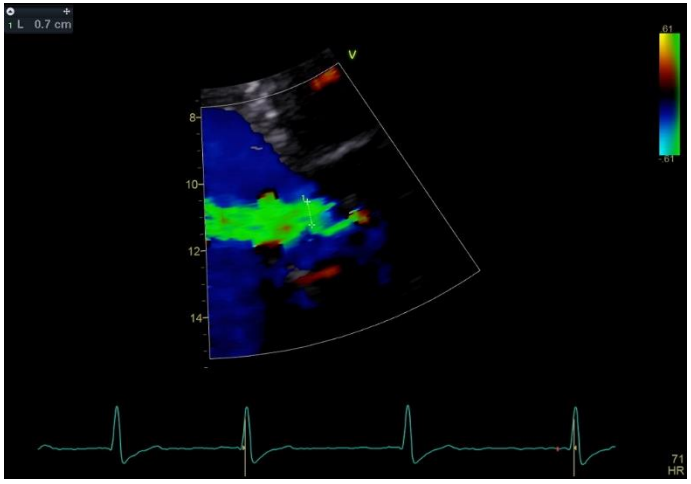
Semikvantifikace AR

Šíře jetu v LVOT – 38%

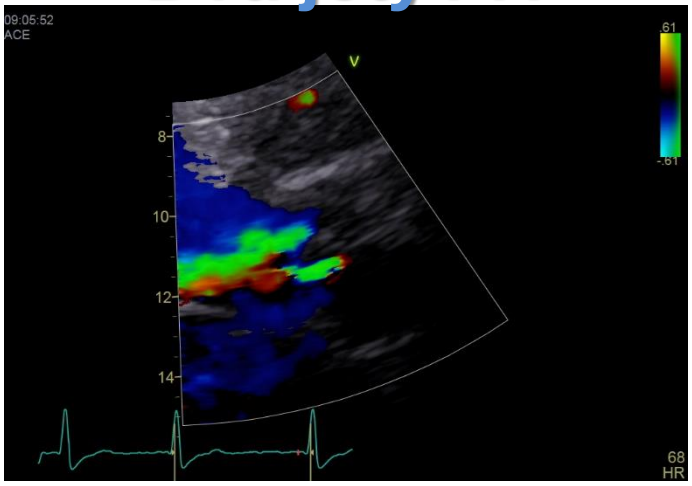


Semikvantifikace AR

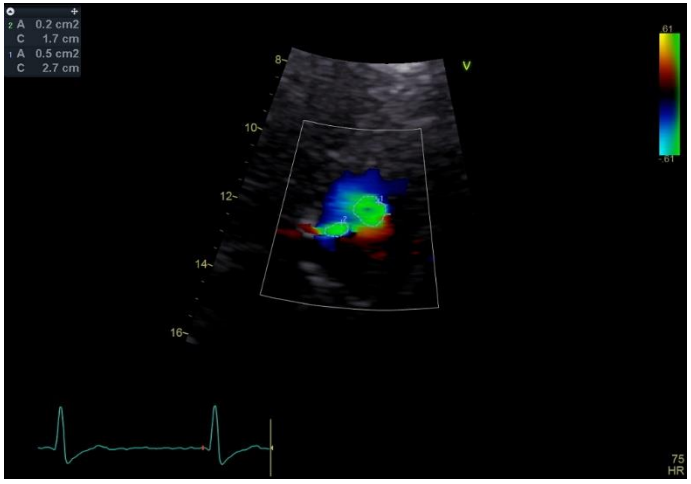
Vena contracta 7 mm



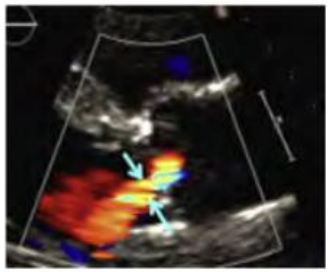
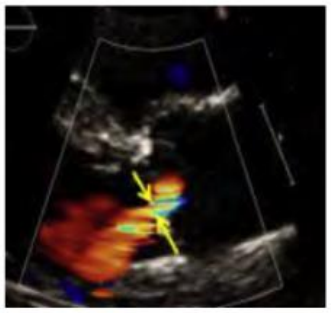
Dva jety??!



Jet area v PSAX a gain ↓↓



Kvalitativní a semikvantitativní hodnocení

Modality	Optimization	Example	Advantages	Pitfalls
Color flow Doppler 2D				
Jet width/ LVOT diameter **≥ 65% LVOT** **u centrálního jetu**	• Long-axis view • Zoomed view • Imaging plane for optimal VC measurement may be different from PISA • Measure in LVOT within 1 cm of the VC		• Simple sensitive screen for AR • Rapid qualitative assessment	• Underestimates AR in eccentric jets • May overestimate AR in central jets as AR jet may expand unpredictably below the orifice • Is affected by the size of the LVOT
Jet area/LVOT area	• Short-axis view • Zoom view • Measure within 1 cm of the VC		• Estimate of regurgitant orifice area	• Direction and shape of jet may overestimate or underestimate jet area
VC **> 6mm**	• Parasternal long-axis view • Zoomed view • Imaging plane for optimal VC measurement may be different from that for PISA • Narrowest area of jet at or just apical to the valve		• Surrogate for regurgitant orifice size • May be used in eccentric jets • Independent of flow rate and driving pressure • Less dependent on technical factors • Good at identifying mild or severe AR	• Problematic in the presence of multiple jets or bicuspid valves • Convergence zone needs to be visualized • The direction of the jet (in relation to the insonation beam) will influence the appearance of the jet

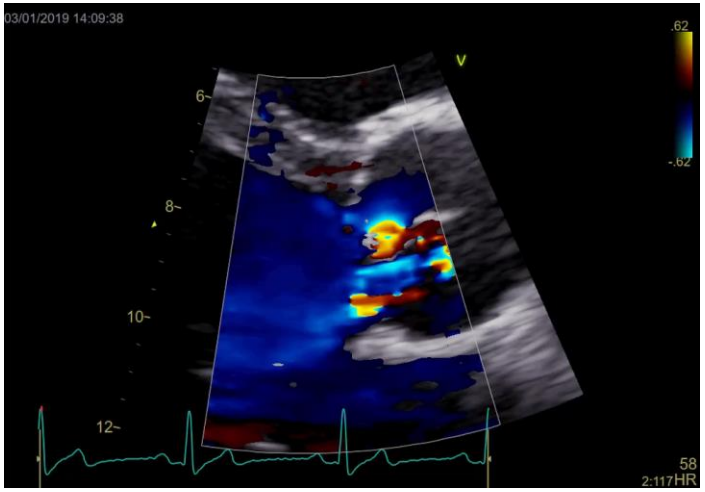
2017 ASE Guidelines

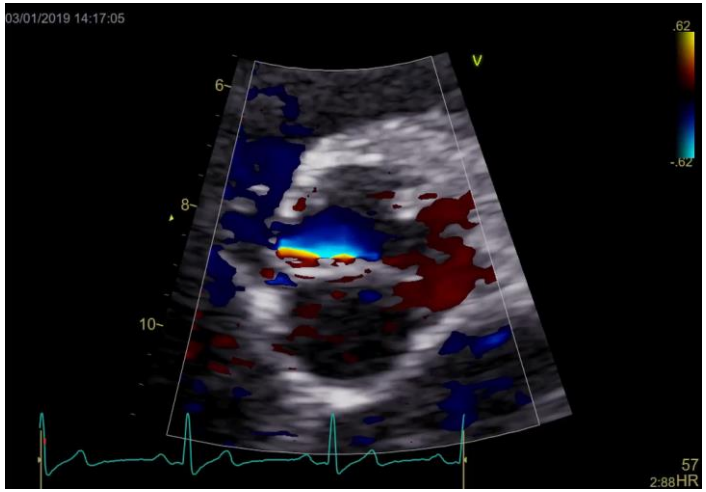
Excentrický jet AR je problém (typicky prolaps cípu či BAV)

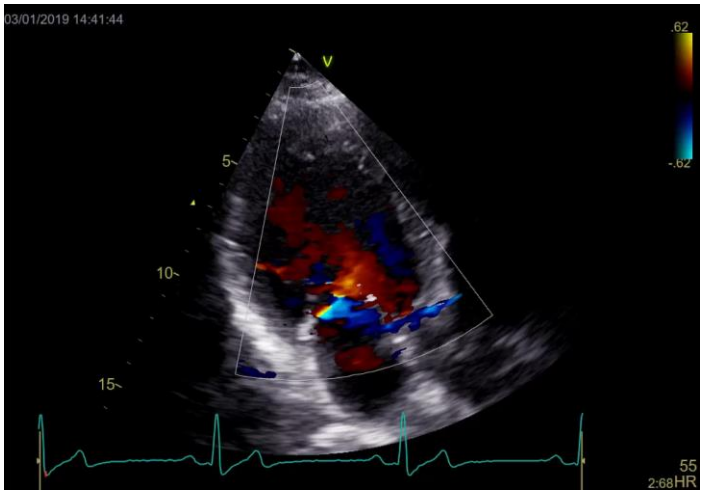
ECHO

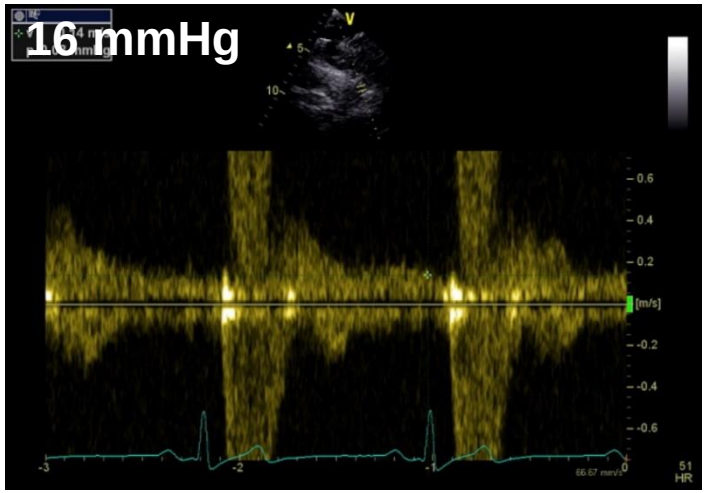
AR 3/4
VC 5 mm
VCA 28 mm2
PW v desc aortě
16 mmHg

EDD 63 mm (≤ 58)
EDVi 84 ml/m2 (<75)
EF 58%
GLS 17%



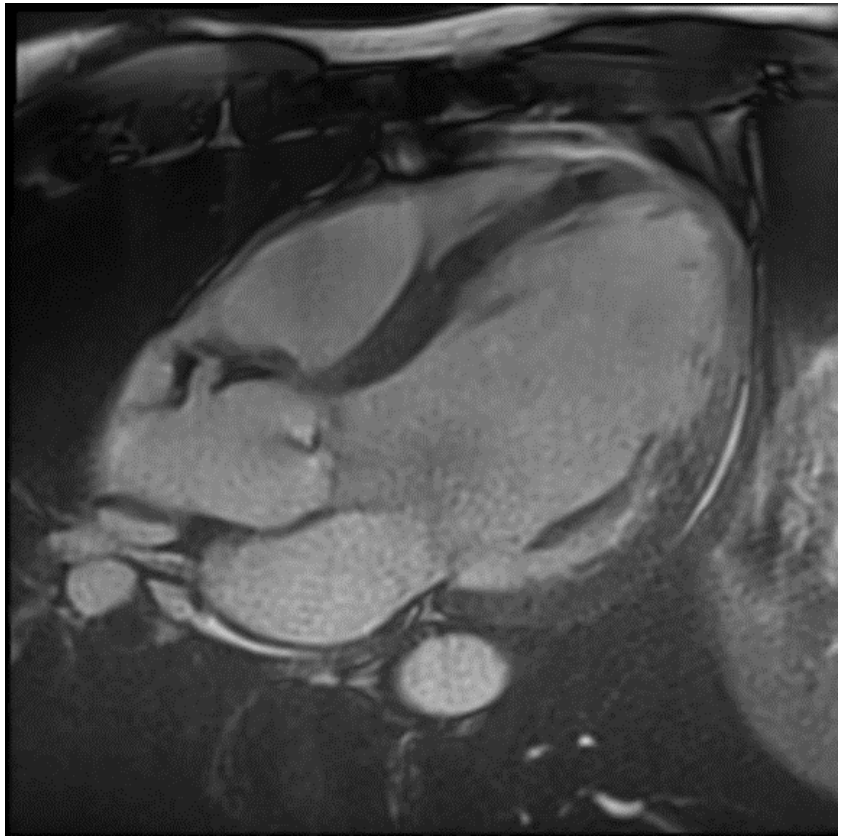




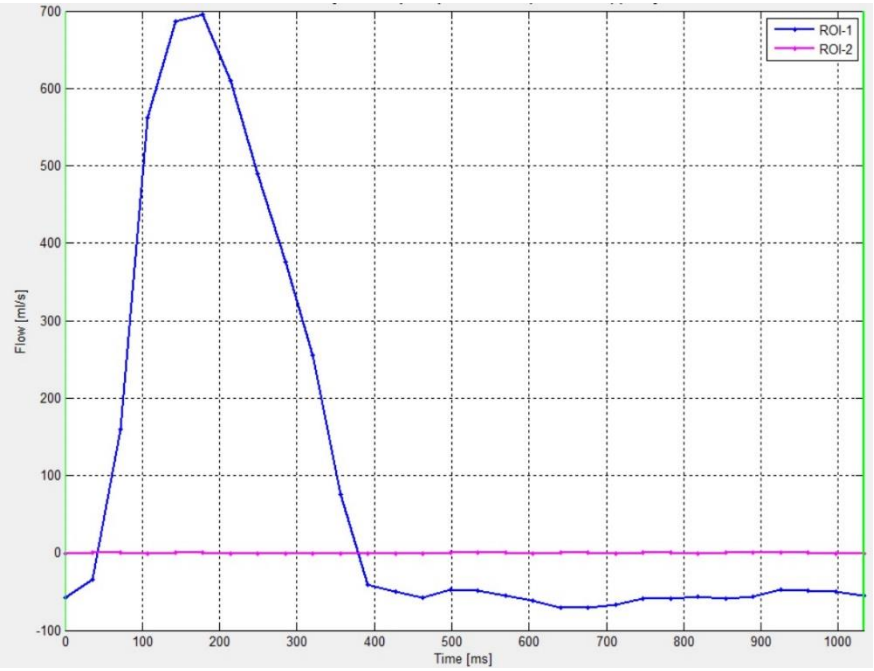


Excentrický jet AR

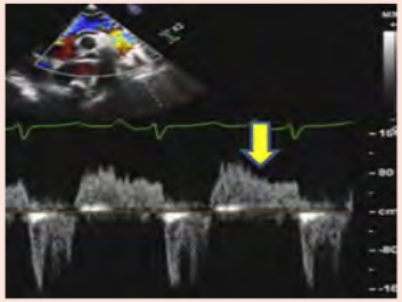
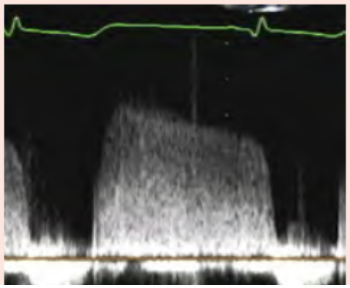
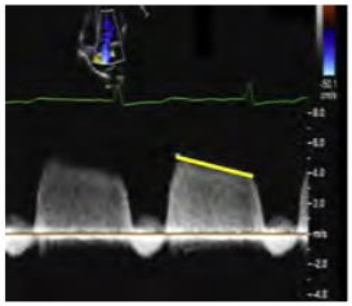
= follow-up 2 roky - nově NYHA II.st. - indikace KCH



EDVi 125 ml (105 ml/m2), EF 54%, GLS 11.2%, RV 46 ml, RF 35%



Kvalitativní hodnocení

Modality	Optimization	Example	Advantages	Pitfalls
Pulsed wave Doppler: Flow reversal in proximal descending aorta	• Align insonation beam with the flow in the proximal descending or abdominal aorta		• Simple supportive sign of severe AR • More specific sign if seen in abdominal aorta • Can be obtained with both TTE and TEE	• Depends on compliance of the aorta; less reliable in older patients • Brief velocity reversal is normal • Can be present in arteriovenous fistula in upper extremity, ruptured sinus of Valsalva • May not be holodiastolic in acute AR
CWD				
Density of regurgitant jet	• Align insonation beam with the flow • Adjust overall gain		• Simple • Density is proportional to the number of red blood cells reflecting the signal • Faint or incomplete jet is compatible with mild or trace AR	• Qualitative • Perfectly central jets may appear denser than eccentric jets of higher severity • Overlap between moderate and severe AR
Jet deceleration rate (pressure half-time)	• Align insonation beam with the flow • Usually best from apical windows • In eccentric jets, may be best from parasternal window, helped by color Doppler		• Simple • Specific sign of pressure relation between aorta and LV • If long, excludes severe AR	• Qualitative • Poor alignment of Doppler beam may result in lower pressure half-time • Affected by changes that modify LV-aorta pressure gradient (if short, implies significant AR or high LV filling pressure)

Rychlost holodiastolického reverzního tok v desc.aortě < 20-21 cm/s

PHT < 200 ms

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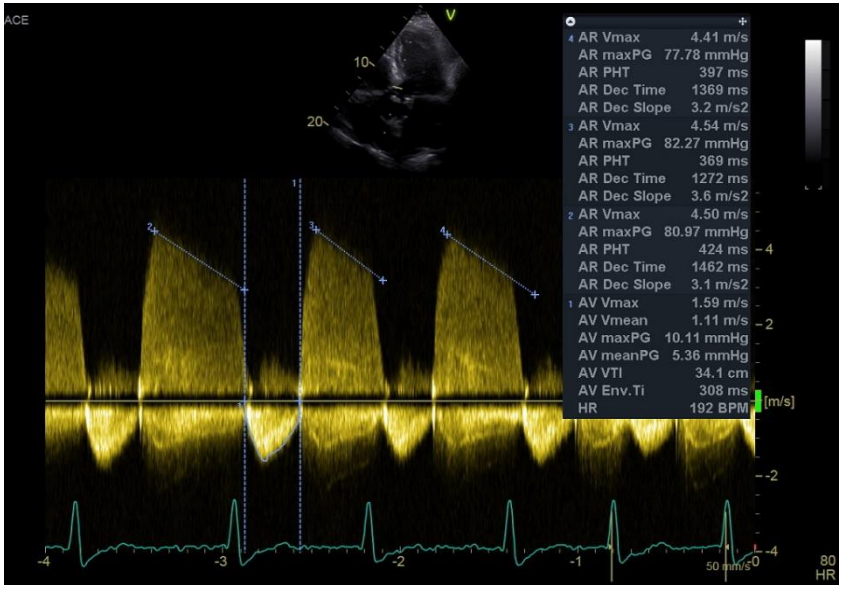
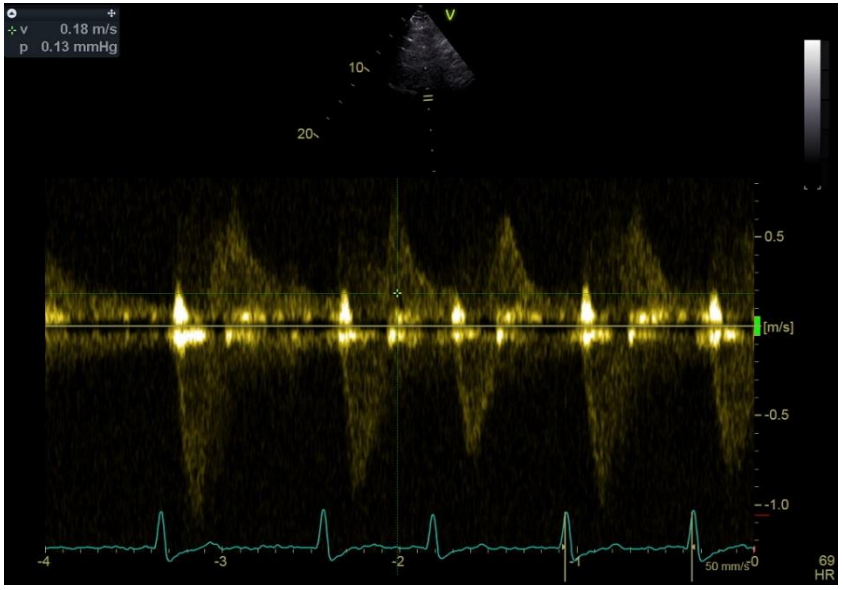
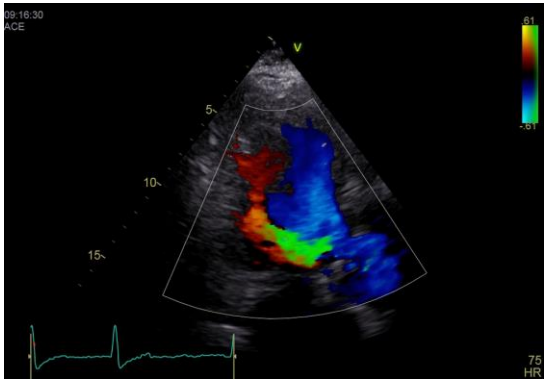
CW a PW

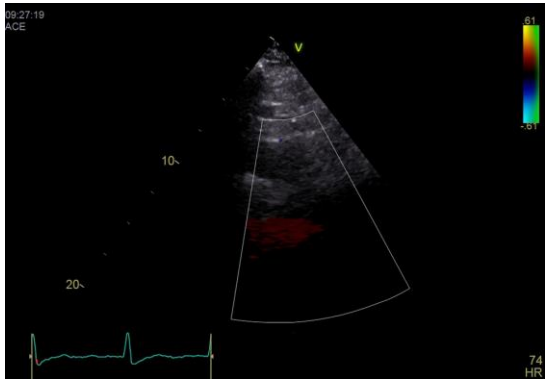
PHT 369 ms



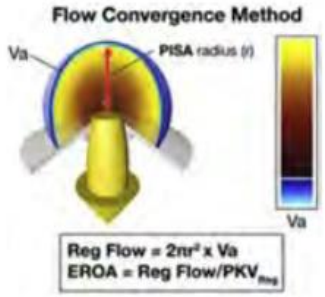
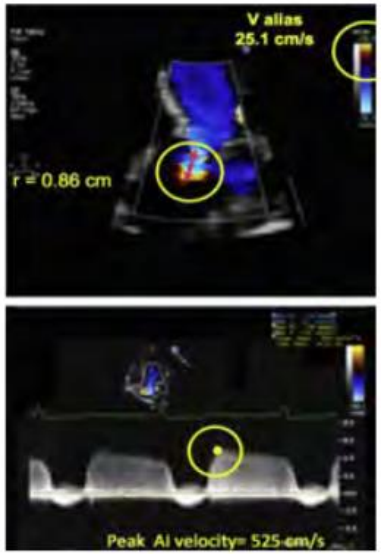
Vmax 18 cm/s







Kvantitativní hodnocení AR

Modality	Optimization	Example	Advantages	Pitfalls
Quantitative Doppler: EROA, regurgitation volume and fraction				
	• Align insonation beam with the flow • Lower the color Doppler baseline in the direction of the jet • Look for the hemispheric shape to guide the best lower Nyquist limit • CWD of regurgitant jet for peak velocity and VTI		• Rapid quantitative assessment of lesion severity (EROA) and volume overload (RVol)	• Feasibility is limited by aortic valve calcifications • Not valid for multiple jets, less accurate in eccentric jets • Limited experience • Small errors in radius measurement can lead to substantial errors in EROA due to squaring of error.

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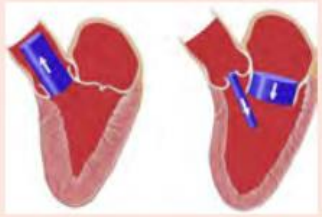
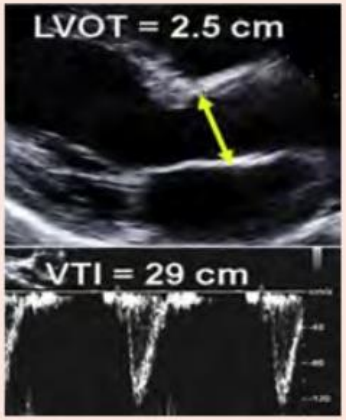
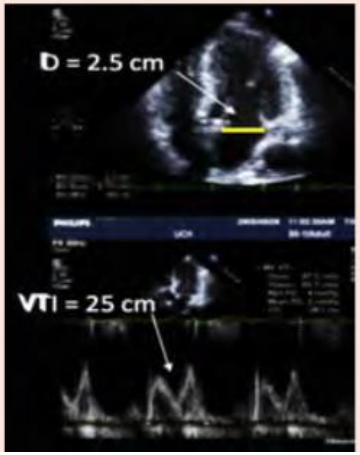
Kvantitativní hodnocení AR

Modality	Optimization	Example	Advantages	Pitfalls
SV method  $RVol = SV_{LVOT} - SV_{MV}$	• LVOT diameter measured at the annulus in systole and pulsed Doppler from apical views at same site • Mitral annulus measured at middiastole; pulsed Doppler at the annulus level in diastole • Total LV SV can also be measured by the difference between LV end-diastolic volume and end-systolic volume. • LV volumes are best measured by 3D. Contrast may be needed to better trace endocardial borders. If 3D not feasible, use 2D method of disks.	 	• Quantitative, valid with multiple jets and eccentric jets. Provides both lesion severity (EROA, RF) and volume overload (RVol) • Verify results using LV end-diastolic volume and LV end-systolic volume	• Difficulties measuring mitral annulus diameter, particularly with annular calcification • Not valid for combined MR and AR, unless pulmonic site is used

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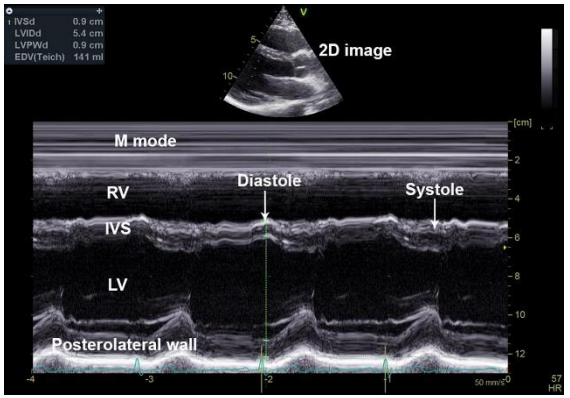
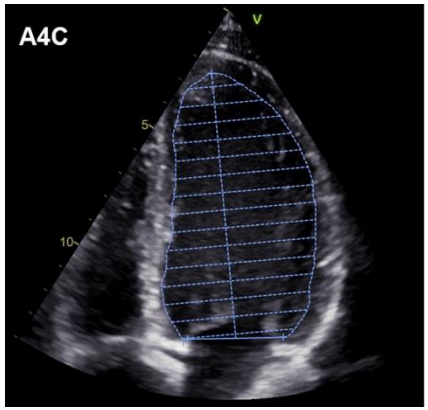
Hodnocení remodelace LK

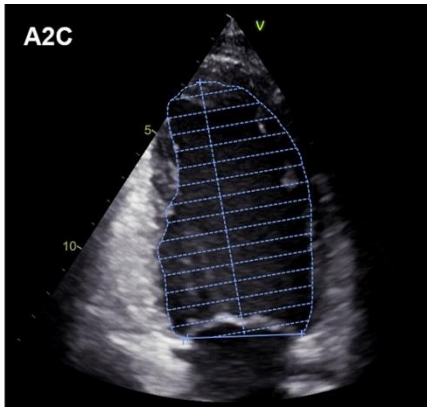
- End-diastolický rozměr
- End-systolický rozměr
- EF LK odhadem

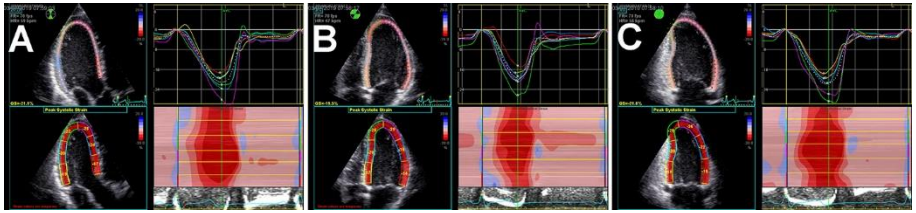


==========

- EF LK biplanárně
- EDVi LK
- ESVi LK
- GLS







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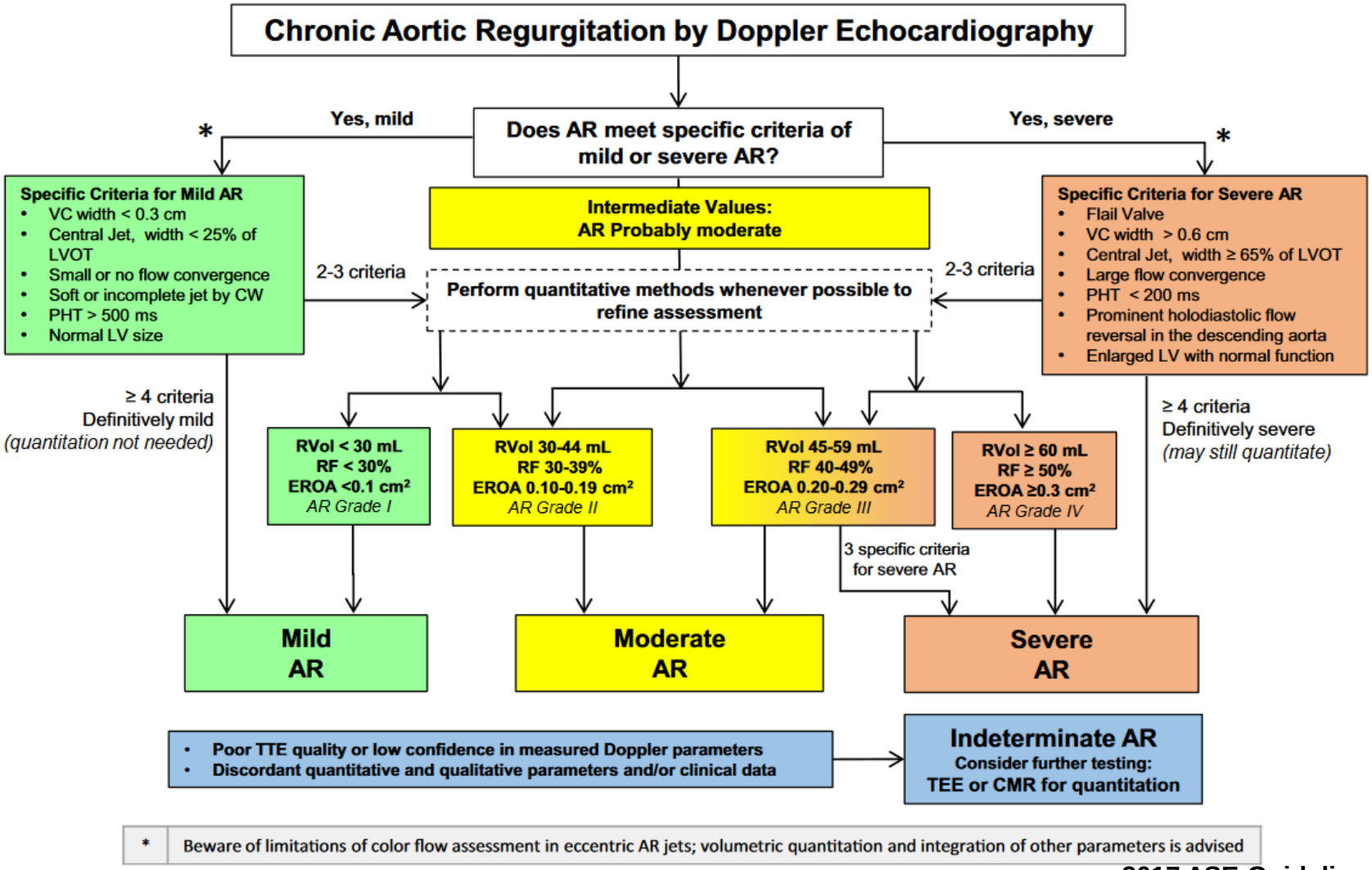
Integrativní přístup ke kvantifikaci



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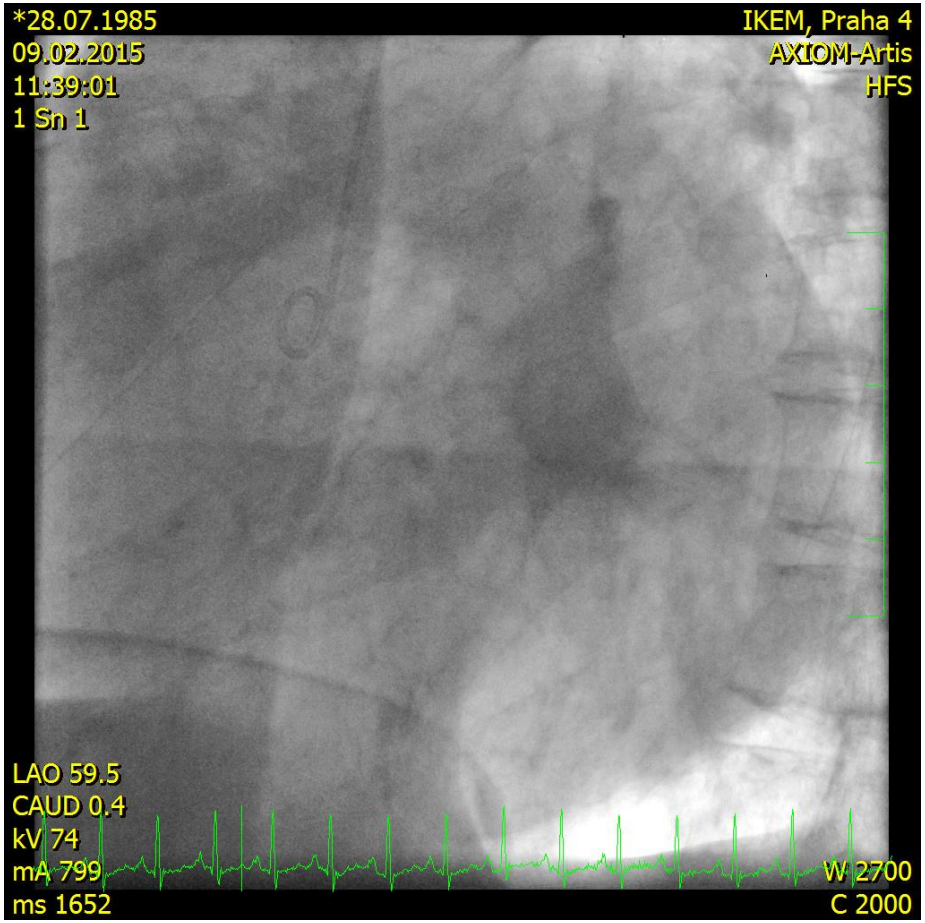
Aortografie

Významná aortální regurgitace



Kdy indikovat MRI u AR

- ECHO nedostatečné kvality
- Diskrepance doppler hodnot a nález na LK
- Diskrepance kliniky a ECHO kvantifikace
- Přesné zhodnocení LK u AR 3-4/4
- BAV k posouzení kořene a asc.aorty

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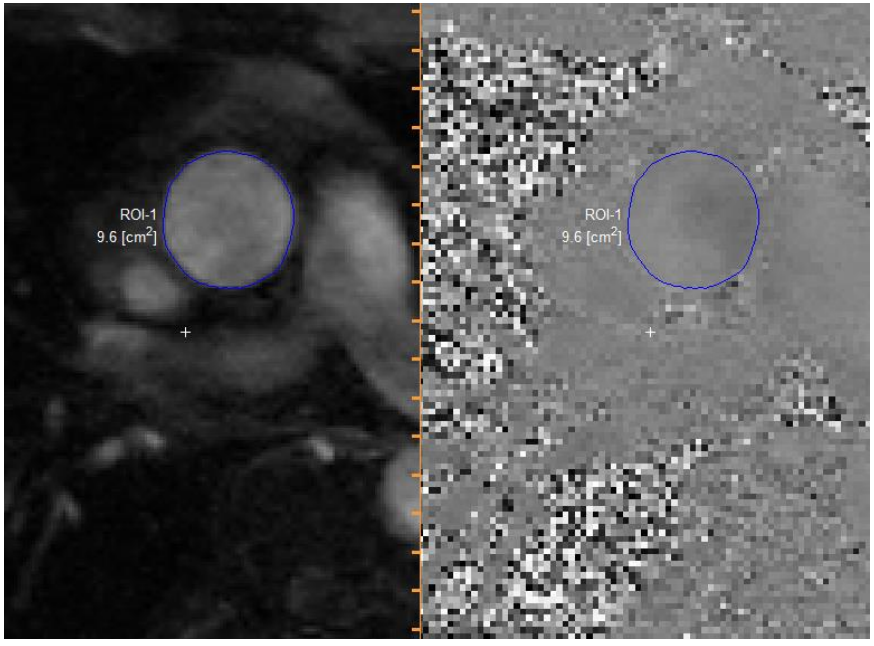
Proč MRI?

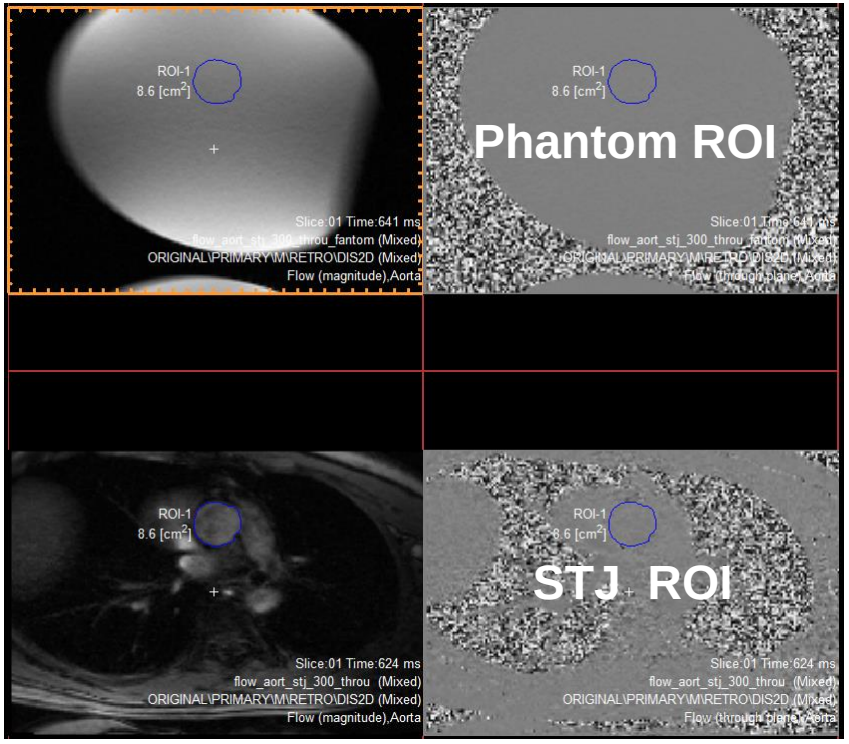
- **MRI disponuje sekvencí schopnou sledovat průtok – phase contrast velocity mapping**

- **MRI je „zlatým standardem“ pro hodnocení parametrů srdečních komor – EF, EDV, ESV, SV**

Phase-contrast velocity mapping
Průtok sinotubulární junkcí

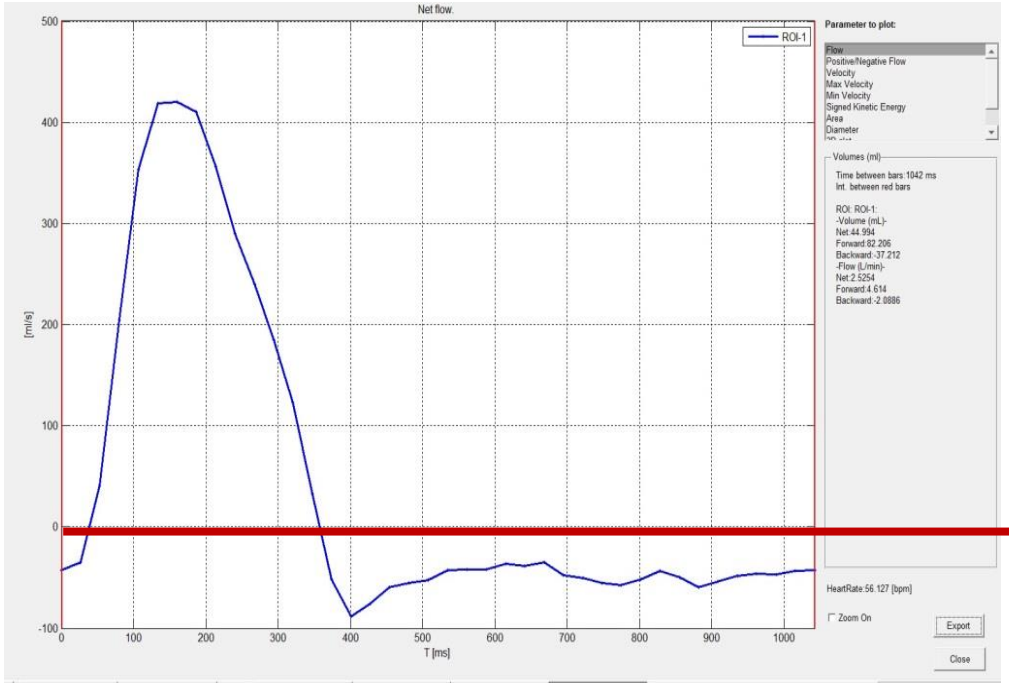
Nezávislý na tvaru reg.ústí
Excentrický jet nevadí





Regurgitační objem (RV) a frakce (RF)

Průtok v STJ



0

Forward flow 82 ml = tepový objem

Backward flow 35 ml = Regurgitační objem - RV

RF 43%

$$RF(\%) = 100 * \frac{RV\ (ml)}{Tepový\ objem\ (ml)}$$

Eddy current

1. Redukce odchylky optimalizací sekvence na konkrétním scanneru

2. Použití Flow phantom nebo korekce postprocesingem

Peter Gatehouse

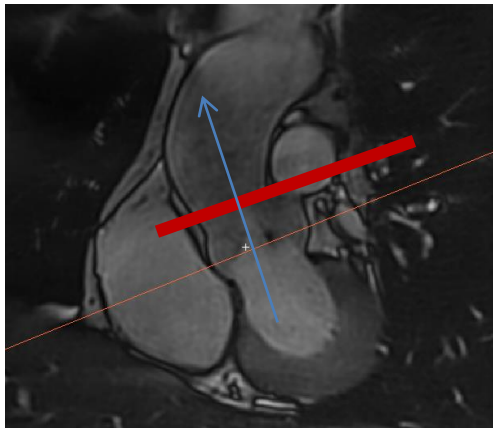
Chyba 0.6 cm/s = v toleranci

2.5% Regurgitační frakce u AR

MP Rolf et al.JCMR 2011

Phase contrast velocity mapping

- Řez vedený přesně kolmo k průtoku krve



- Řez umístění v isocentru magnetu (ISO)

  minimalizace vlivu nehomogenity pole

Sinusový rytmus!!!

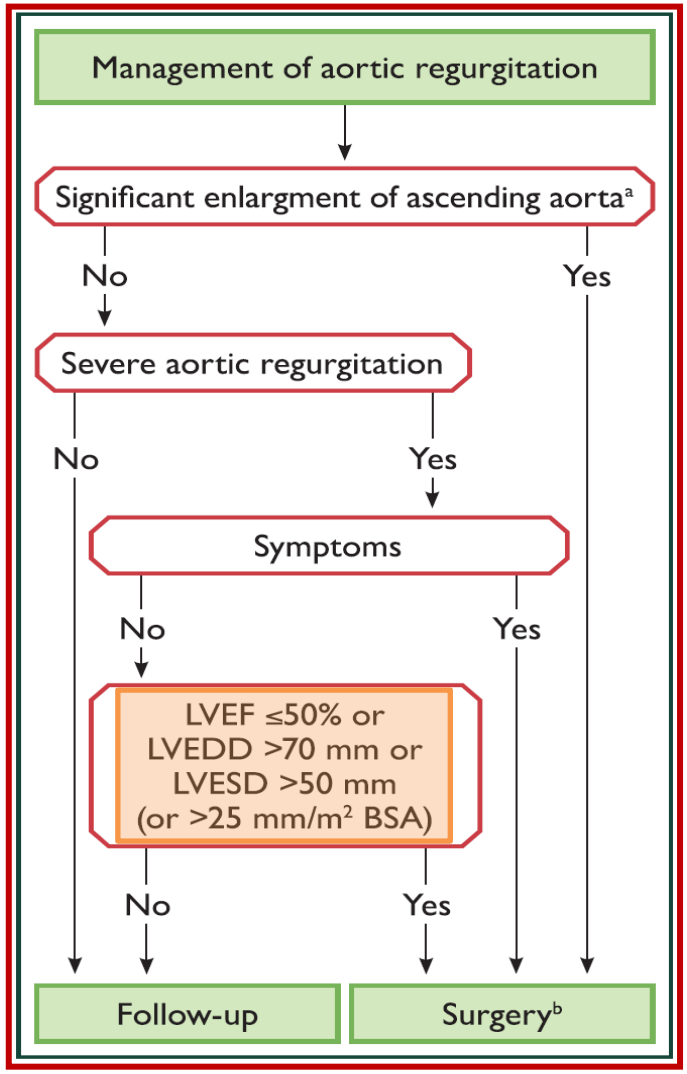
VENC scout Siemens

VENC 100

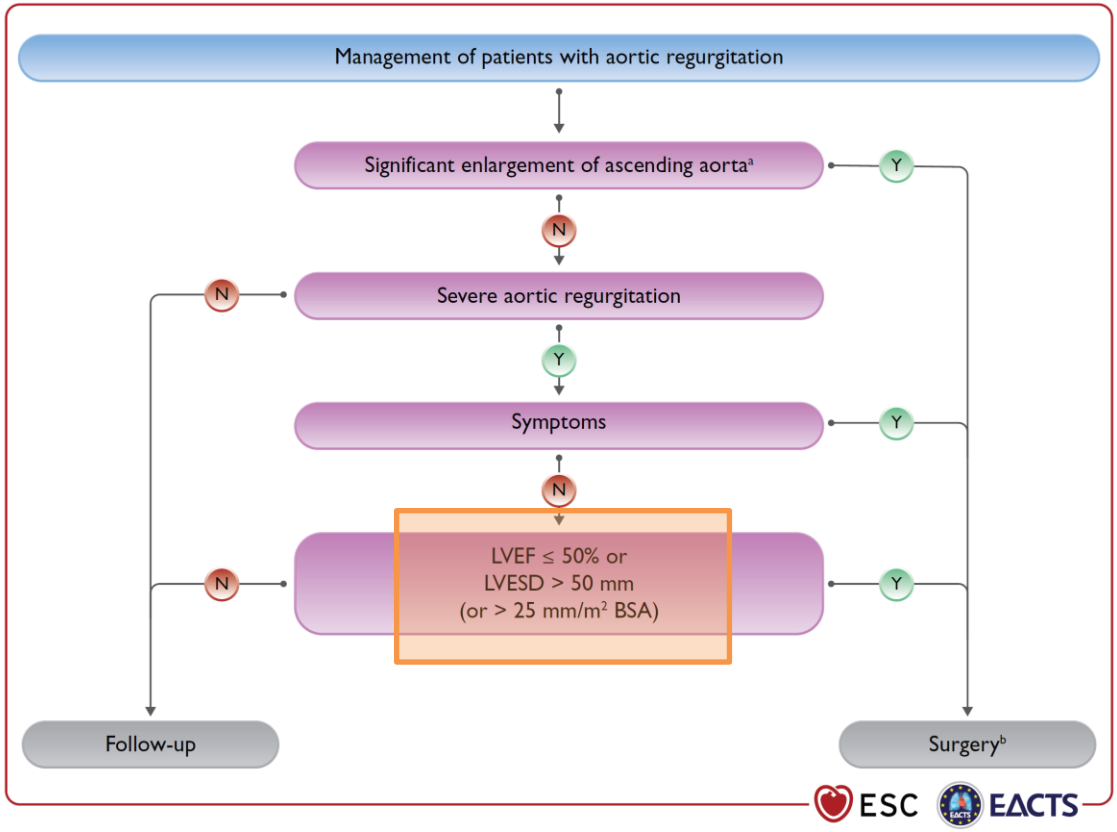
VENC scout Siemens

VENC 160

Management AR

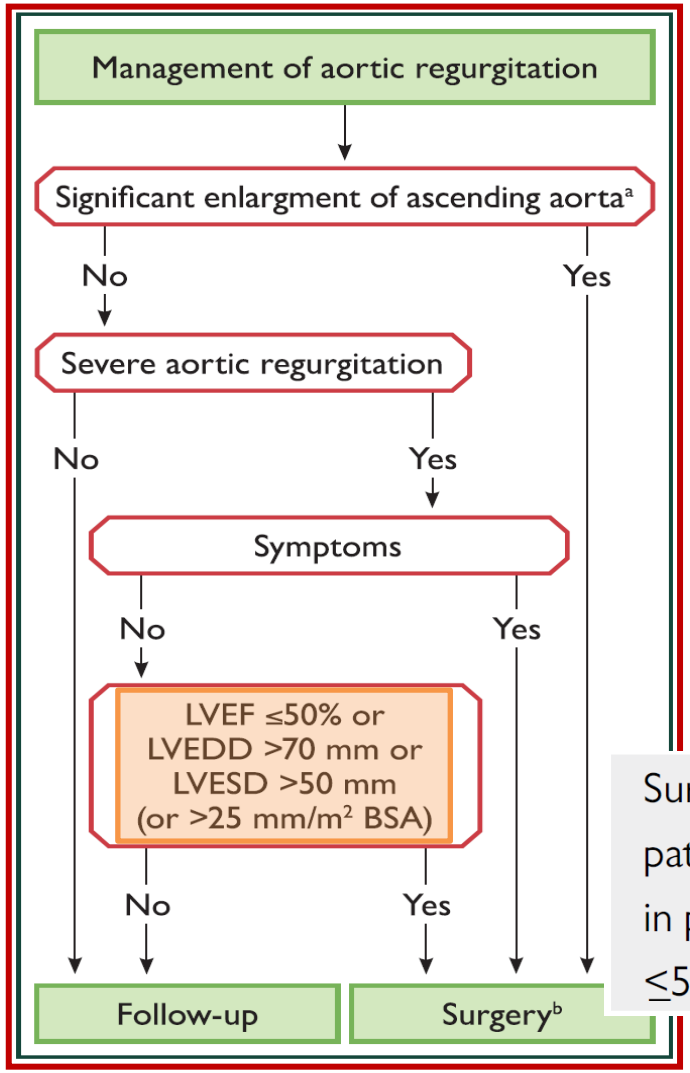


ESC guidelines 2012-2017

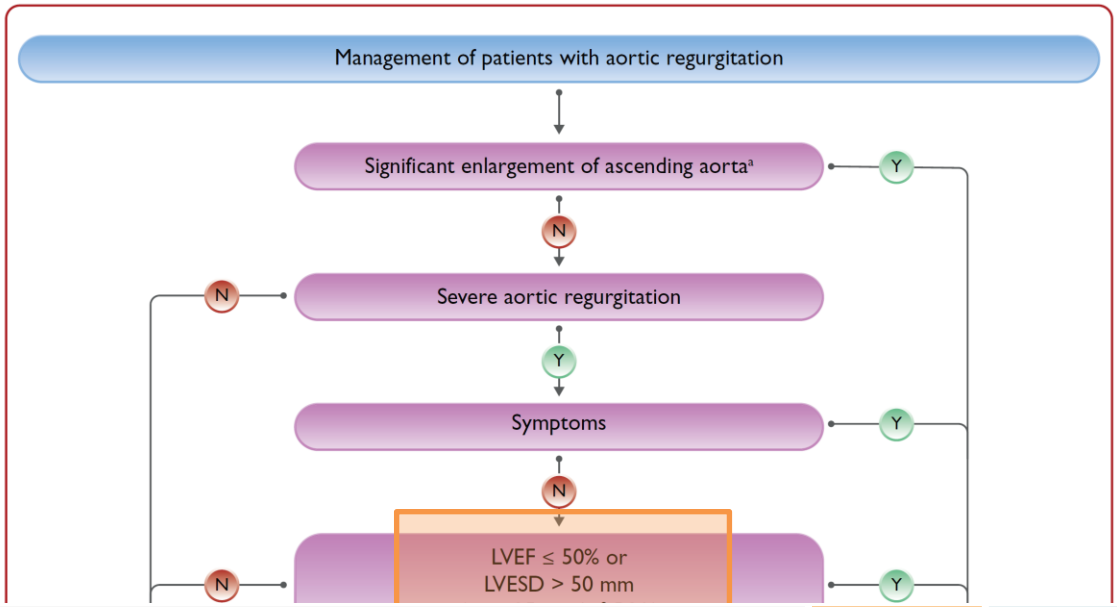


ESC guidelines 2021

Management AR



ESC guidelines 2012-2017



Surgery may be considered in asymptomatic patients with LVESD >20 mm/m^2 BSA (especially in patients with small body size) or resting LVEF ≤55%, if surgery is at low risk.	IIb	C

ESC guidelines 2021

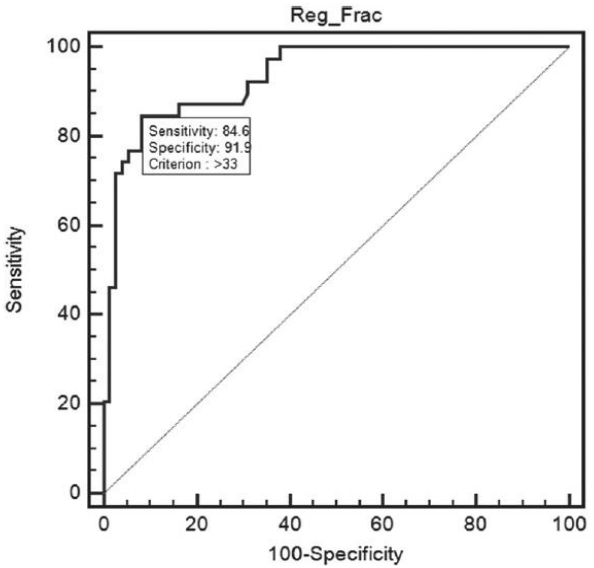
Timing chirurgického zákroku

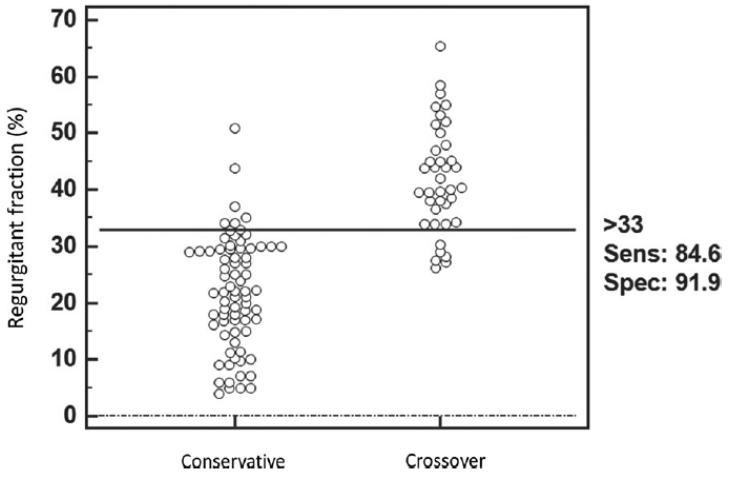
Regurgitační frakce > 33%

85% bylo operováno z 39 pts

Regurgitační frakce ≤ 33%

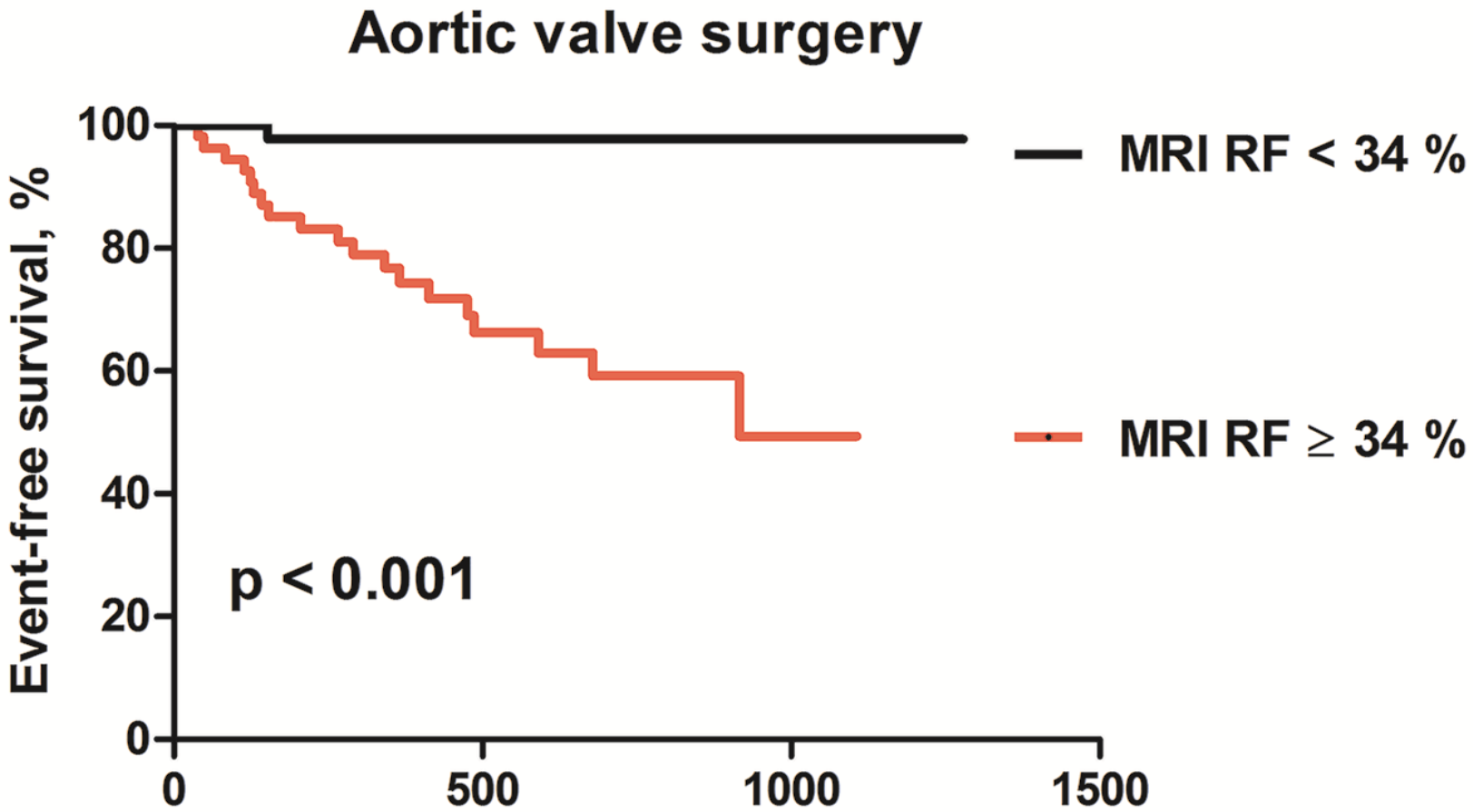
8% operováno ze 74 pts





Myerson SG et al. Circulation 2012

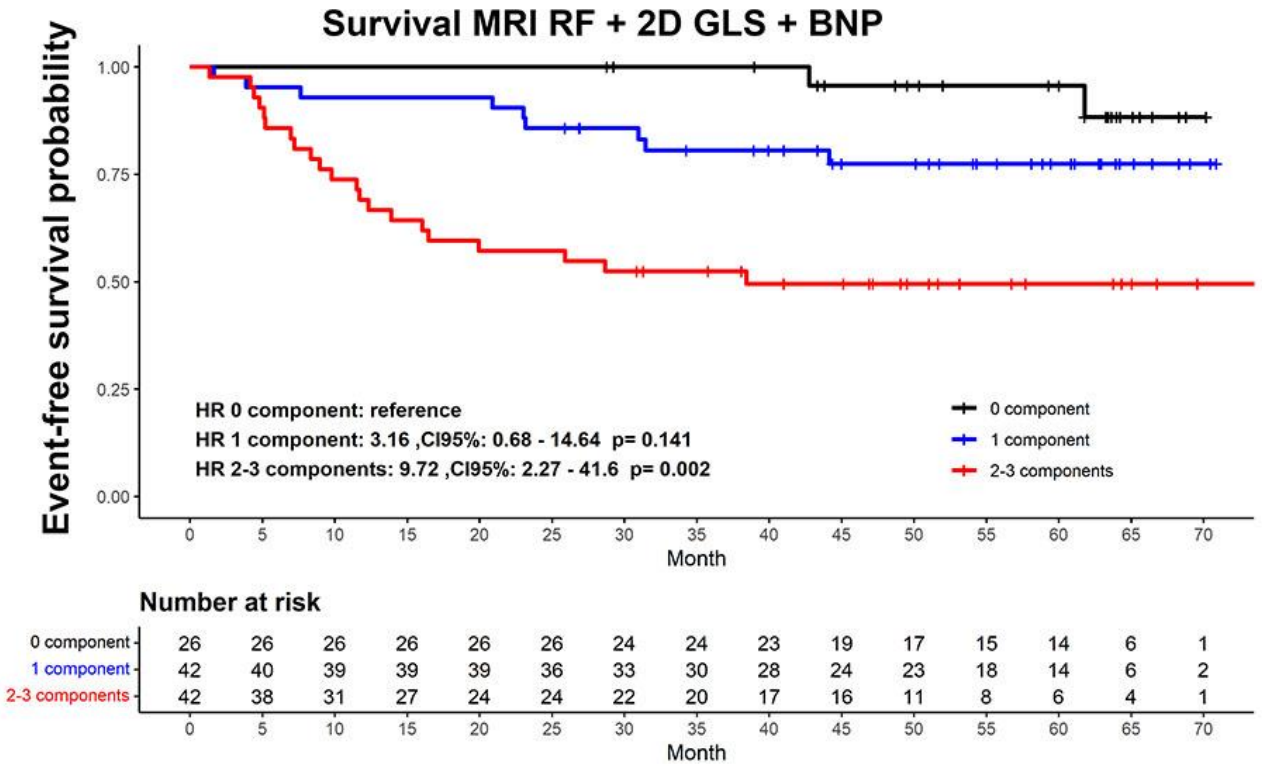
Timing chirurgického zákroku



Kockova et al. 2019

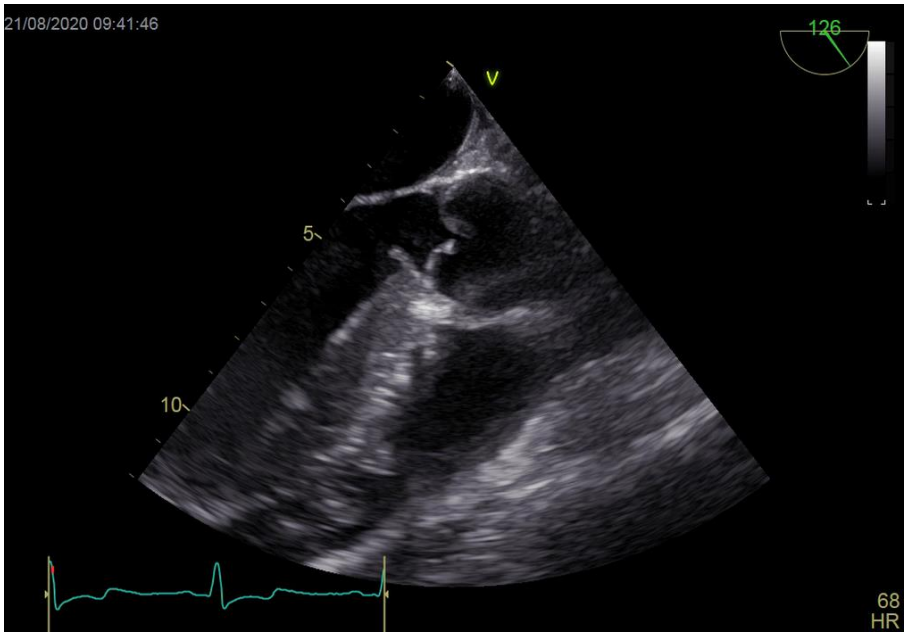
MOLLI-GLS-Hx

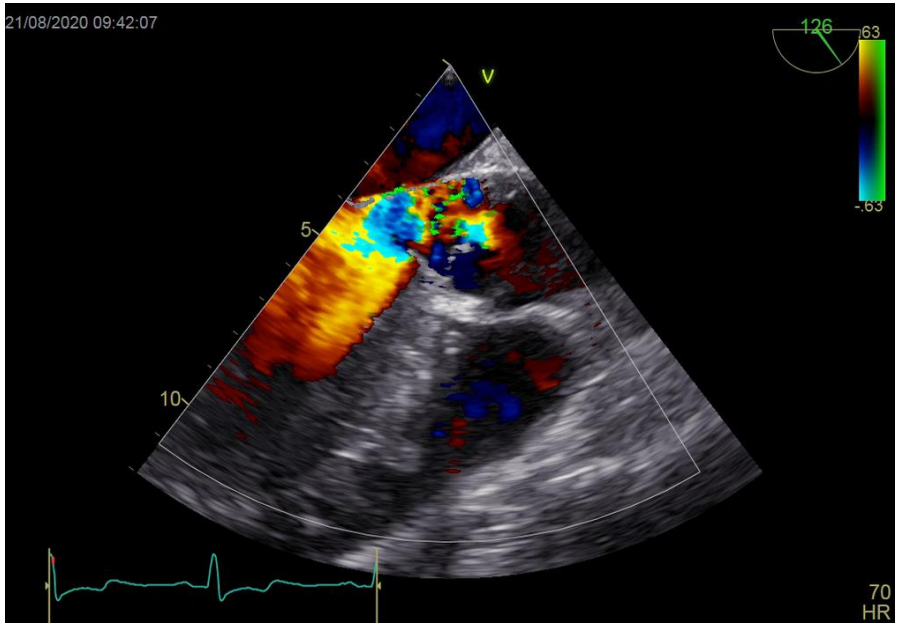
IKEM	129 pts s izolovanou AR
VFN Praha	2015-2020
FNKV Praha	43 operací dle guidelines
FNHK Hradec Králové	77% BAV
Nemocnice na Homolce	4% unikuspidní chlopeň



Kombinovaná vada

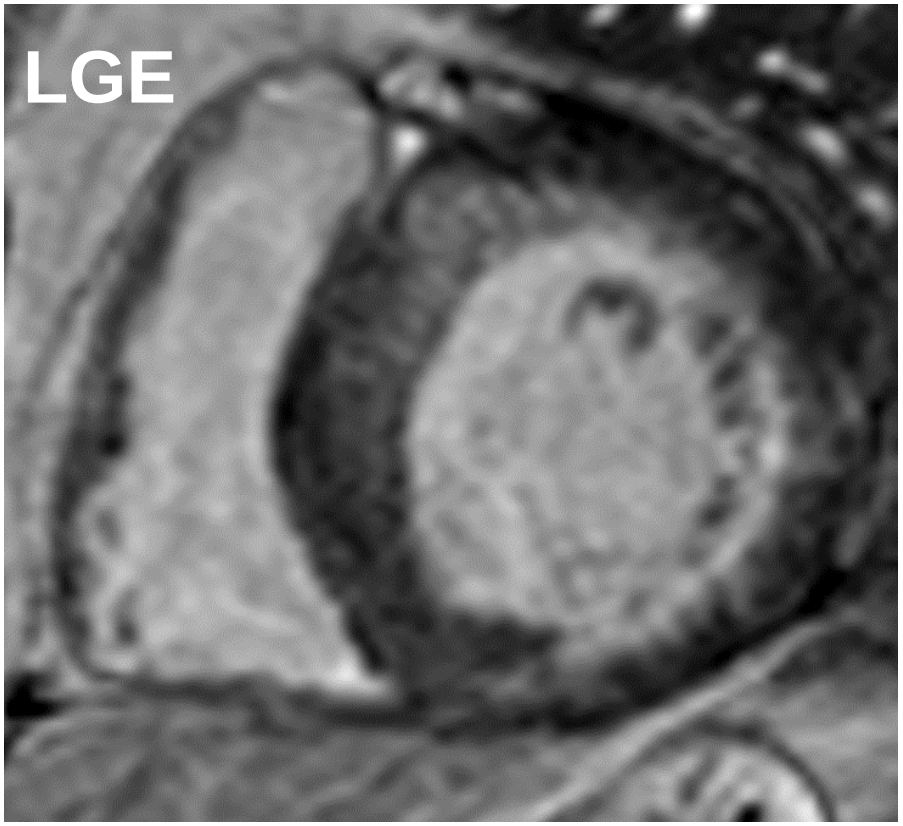
Vrozená významná subvalvární stenóza+AR 4/4
NYHA I.st.
ECHO: EDD 53 mm, IVS 16 mm, ZS 14 mm
PG max v CW na AV chlopni 106/62 mmHg při subvalvární
Obstrukci, AR 4/4 na 3-cípé chlopně bez stenózy

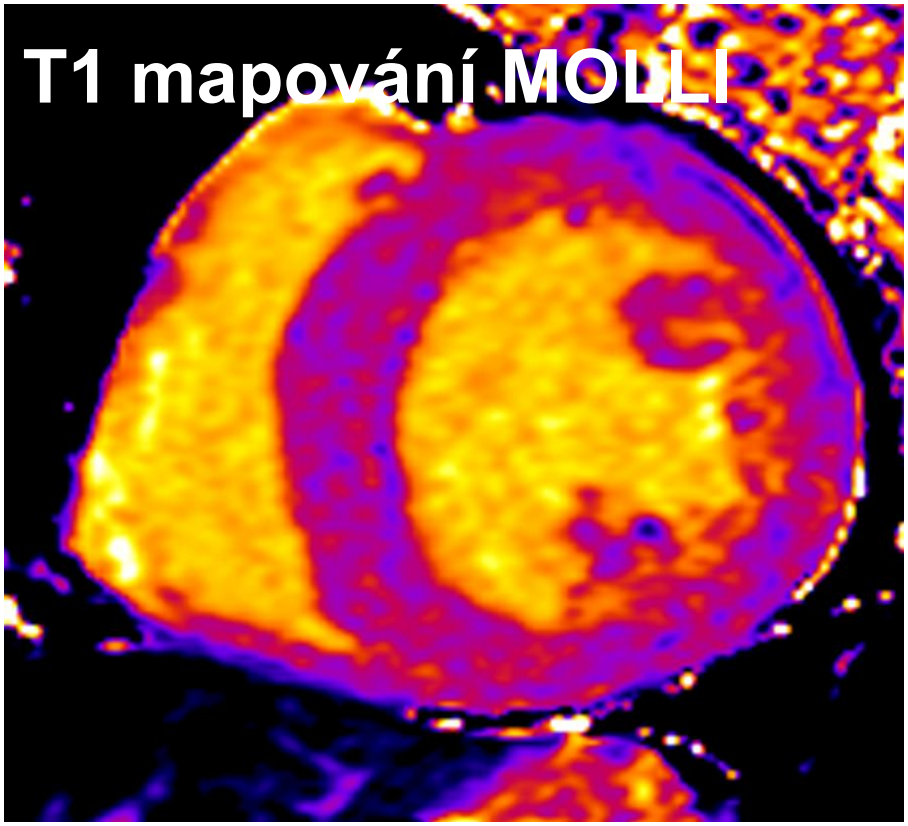




Fibróza myokardu u asymptomatické významné kombinované aortální vady

- **RF 47%, IVS šíře 18 mm, rozsáhlá fibróza v LGE, T1 relaxační čas 1024 ms**





Chirurgická řešení AR

Plastika aortální chlopně - první volba

	ROSS	BIO	MECH
Průměrná délka follow-up (roky)	7	8	6
Průměrný věk (roky)	42	50.7	48
Časná mortalita (%)	2	3.3	3.15
Pozdní mortalita (%/rok)	0.59	2.39	1.55
Krvácivé komplikace (%/rok)	Low	0.22	0.35
Tromboembolické příhody (%/rok)	Low	0.53	0.90
Tromboza chlopně (%/rok)	Low		0.14
Endokarditida (%/rok)	Low (1/2 of mech.)	0.48	0.41
Reoperace (%/rok)	Autograft 0.83+RVOT 0.47	0.82	0.51
Odhad délky života pro 45 l.pac.	30 (31N)	21 (32N)	19 let (34 N)
Reoperace (lifetime) (%)	49 autograft, 19 RVOT	78	10
Krvácivé komplikace (lifetime) (%)	0	5	15
Tromboembolické příhody (%)	0	12	18

The Ross Procedure: A Systematic Review,Meta-Analysis, and Microsimulation. JRG Etner, P Grashuis et al. Circulation 2018

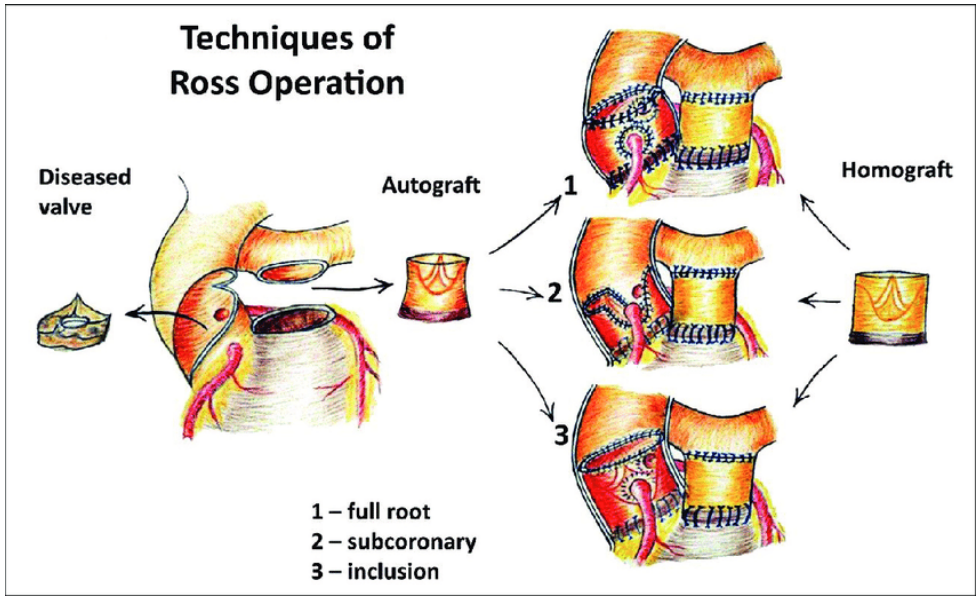
Mechanical aortic valve replacement in non-elderly adults: meta-analysis and microsimulation. NM Korteland et al. EHJ 2017

Bioprosthetic Aortic Valve Replacement in Nonelderly Adults. JRG Etner et al. Circulation 2019

Ross

Neoaortální chlopeň (vlastní pulmonální chlopeň v aortální pozici)

Homograft v pulmonální pozici



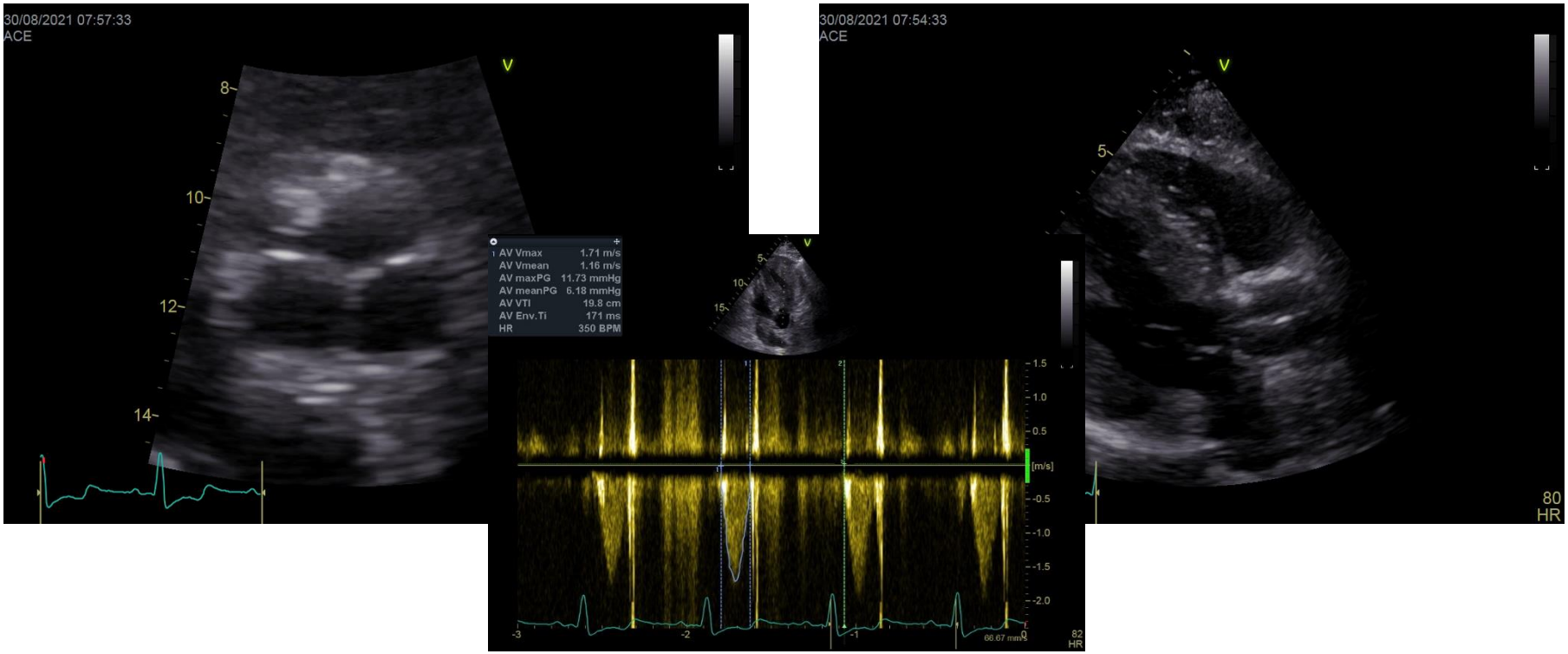
Researchgate.net

Výkon podle Ozakiho

Shigeyuk Ozaki, PhD, in 2007

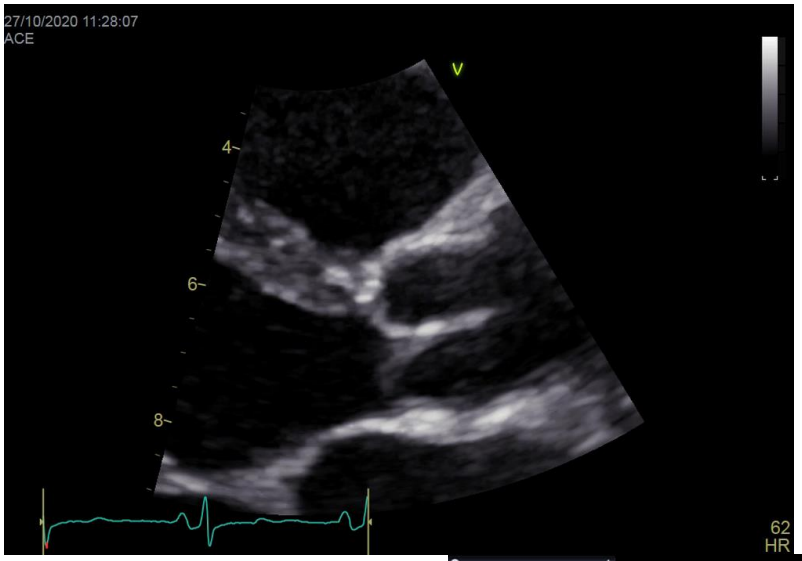
Boston Children's Hospital 2014

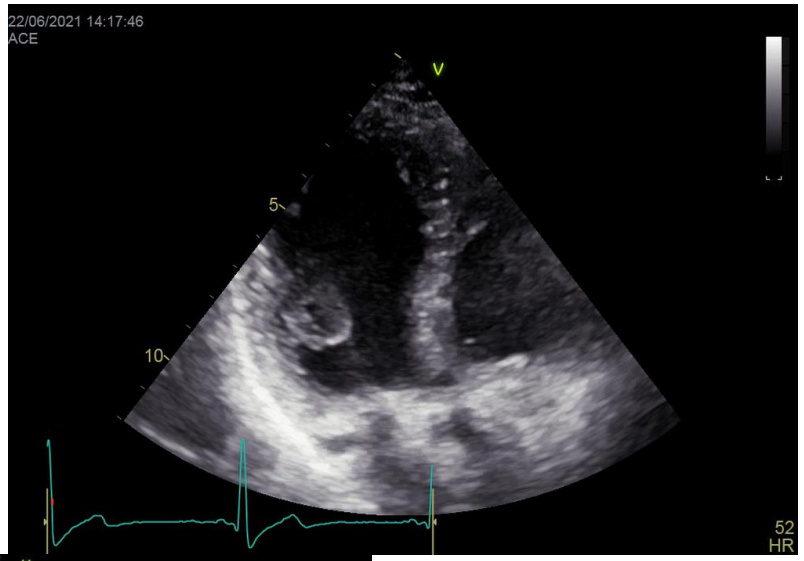
Cípy aortální chlopně z autologního perikardu ošetřené glutaraldehydem

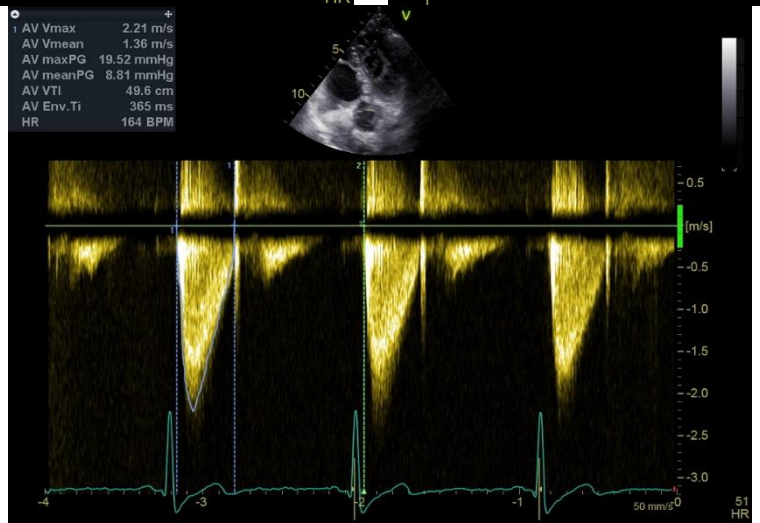


Výkon podle Ozakiho

45 letá žena, 2 roky po výkonu







PG 20/9 mmHg

Akutní aortální regurgitace

- **Endokarditidida**
- **Disekce aorty**
- **Trauma**
- **Obvykle hemodynamická nestabilita, nízký srdeční výden, plicní edém – chirurgický zákrok nutný**

Děkuji za pozornost

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