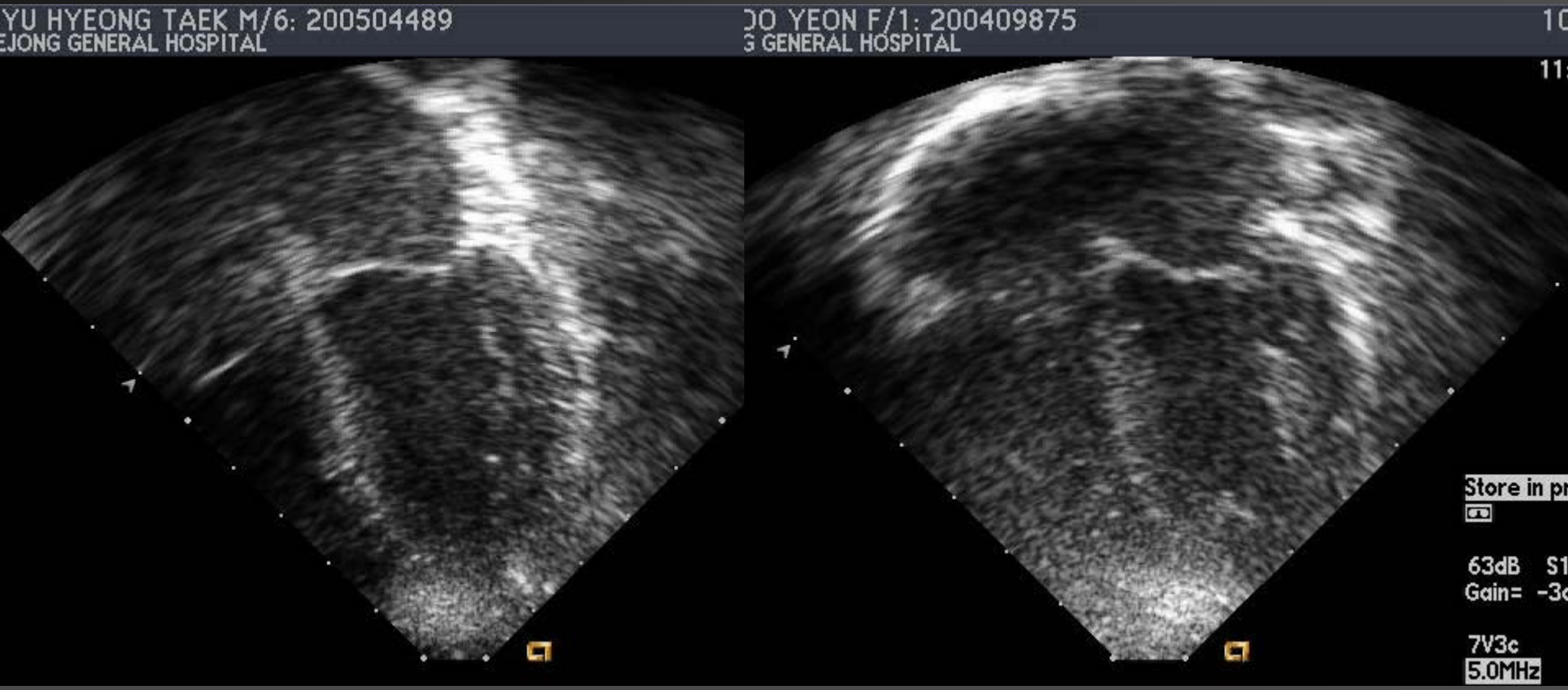
Diastolic Dysfunction in Congenital Heart Disease

장기영
세종병원 소아과


YU HYEONG TAEK M/6: 200504489
EJONG GENERAL HOSPITAL
DO YEON F/1: 200409875
G GENERAL HOSPITAL
Store in pr
63dB
Gain=
7V3c
5.0MHz

Introduction

- Diastolic Dysfunction(DD)

  - Abnormalities in mechanical function during diastole(Myofibrils do not rapidly or completely return to resting length).
  - occurs when diast. Process are prolonged, slowed, or incomplete.
  - occur in normal or abnormal systolic function, in the presence or absence of a clinical symptom of heart failure.

- Diastolic heart failure

  - Symptoms and signs of hear failure, preserved systolic function, abnormal diastolic function.
  - occurs when ventricle is unable to accept an adequate volume during diastole.

- Diastolic dysfunction(DD)
  - 30-40 % of all CHF.
  - DD precede onset of systolic dysfunciton.

→ important determinant in ped. cardiac dz
; oversight (due to difficult to diagnose,
not available normal data in ped.)

Diagnostic Criteria

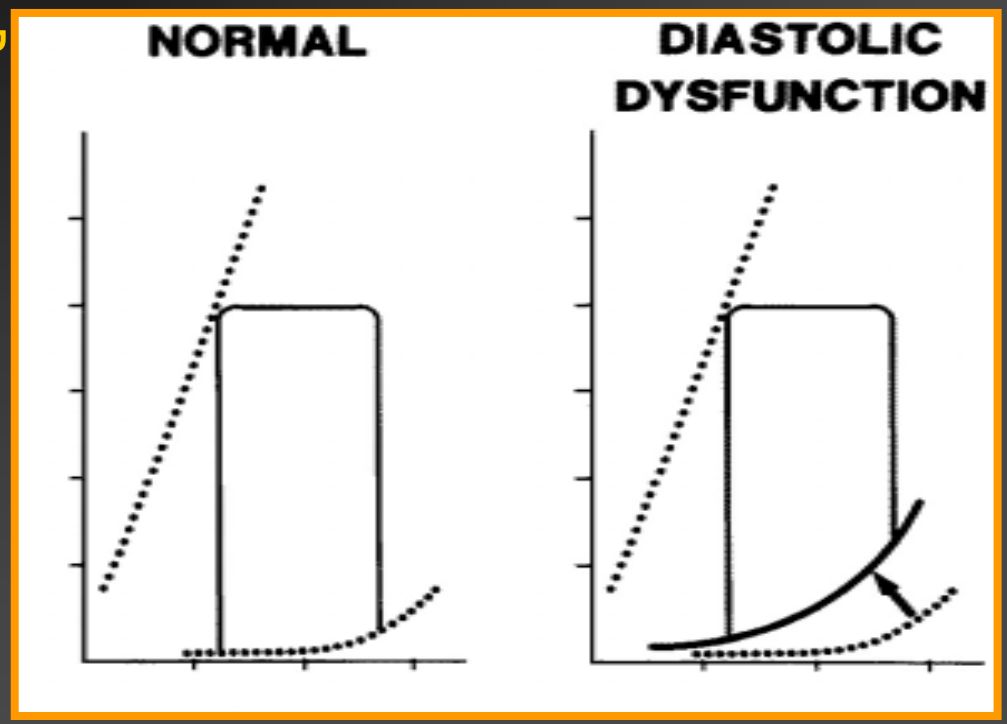
- By European study Group (1998)
  - Signs or symptoms of CHF
  - normal LV systolic function
  - evidence of abnormal LV relaxation, filling, diastolic stiffness.

- By Vasan and Levy (2000)
  - clinical signs and Sx of CHF
  - objective evidence of an EF>0.5 within 72 hrs
  - evidence of LV diast. Dysfunction on cath.

Mechanism of DD

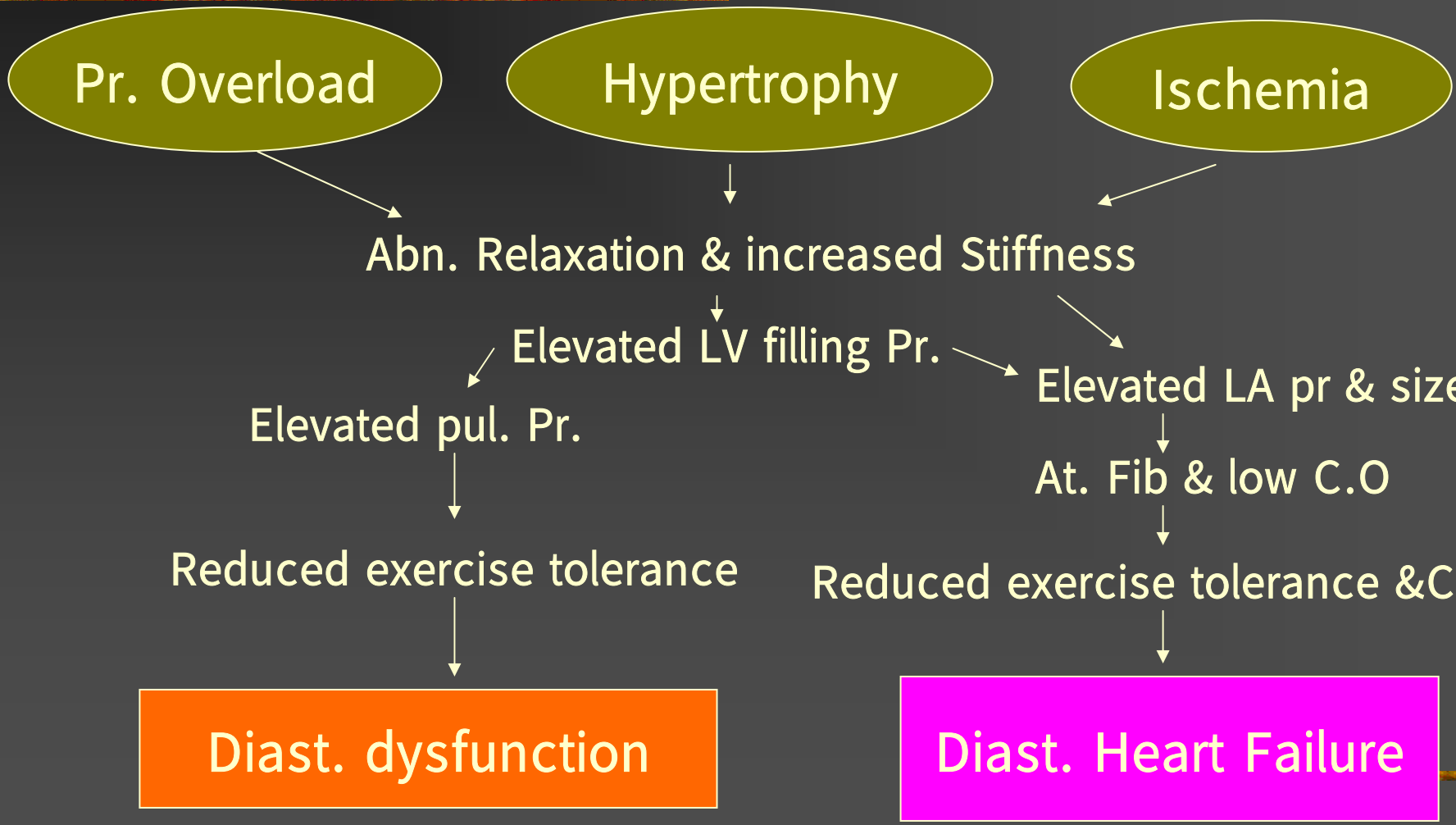
- Intrinsic to the Cardiomyocyte
  - abnormal Calcium homeostasis
- Abnormalities in extracellular matrix
  - alterations in collagen
- Neurohomonal Activation
  - renin-angiotensin-aldo.

Pressure – Volume Loop



- *Chamber stiffness is increased*
- *Diminished capacity to fill at low diast. Pr.*

Pathophysiology of DD



Stages of Diast. Dysfunction

- Stage I
  - reduced LV filling in early diastole
  - normal LV, LA pr & normal compliance
- Stage II
  - pseudonormalization
  - marked diastolic dysfunction
- Stage III
  - severe restrictive diastolic filling
  - marked decrease in LV compliance

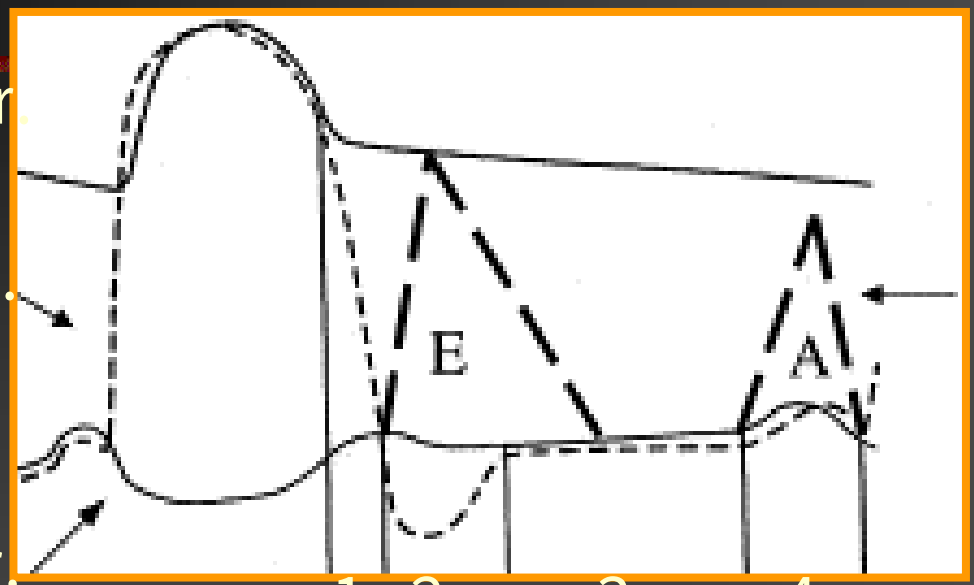
Measurement of Diast. function

- Active Relaxation
  - IVRT
  - dP/dT_{min}
  - Tau(time constant of relaxation)

- Passive Stiffness
  - Kc(chamber stiffness constant)
  - Km(myocardial stiffness constant)

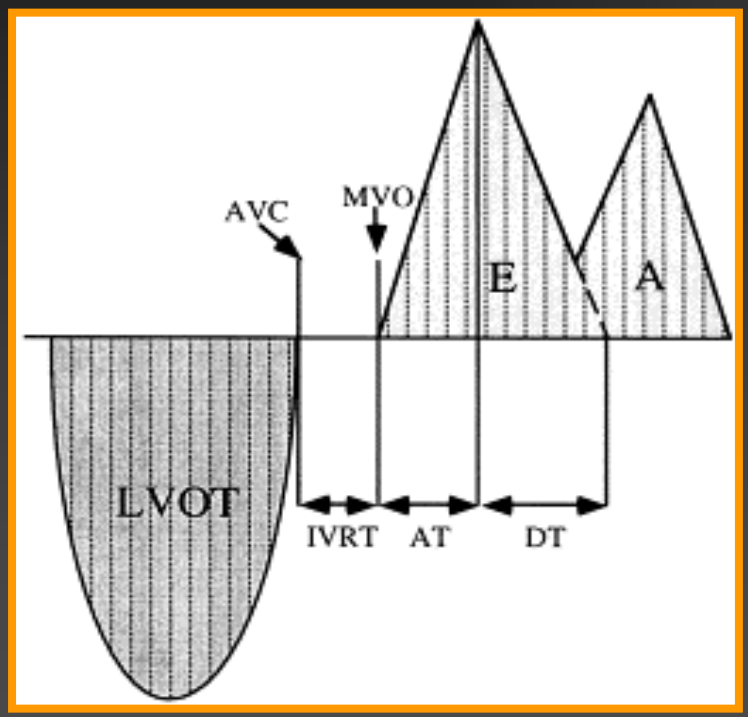
Assessment

4- Phase of Diastole

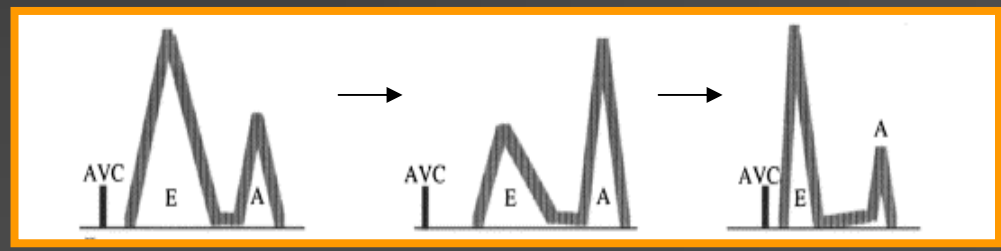


1. Isovolumic relaxation – energy consuming process
2. Rapid filling phase
3. Slow filling phase
4. Atrial systole phase

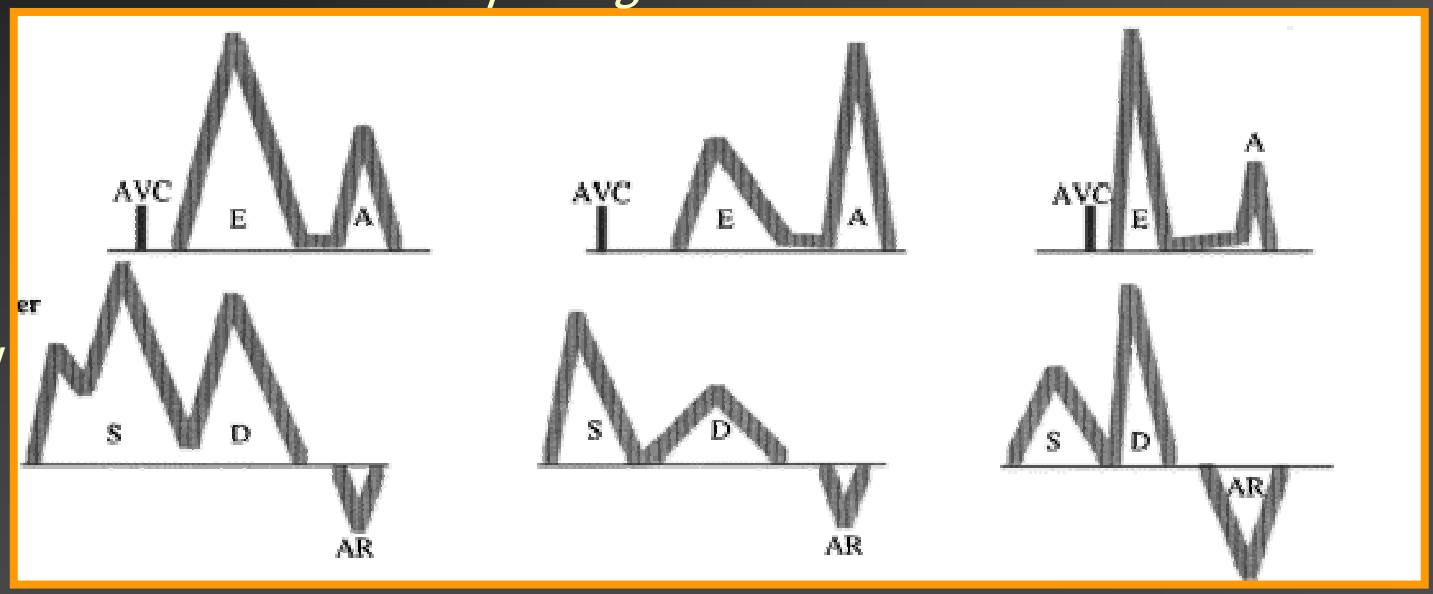
Isovolumic Relaxation Time



- IVRT: AVC - MVO
- Useful method for f/up abnormal relaxation.

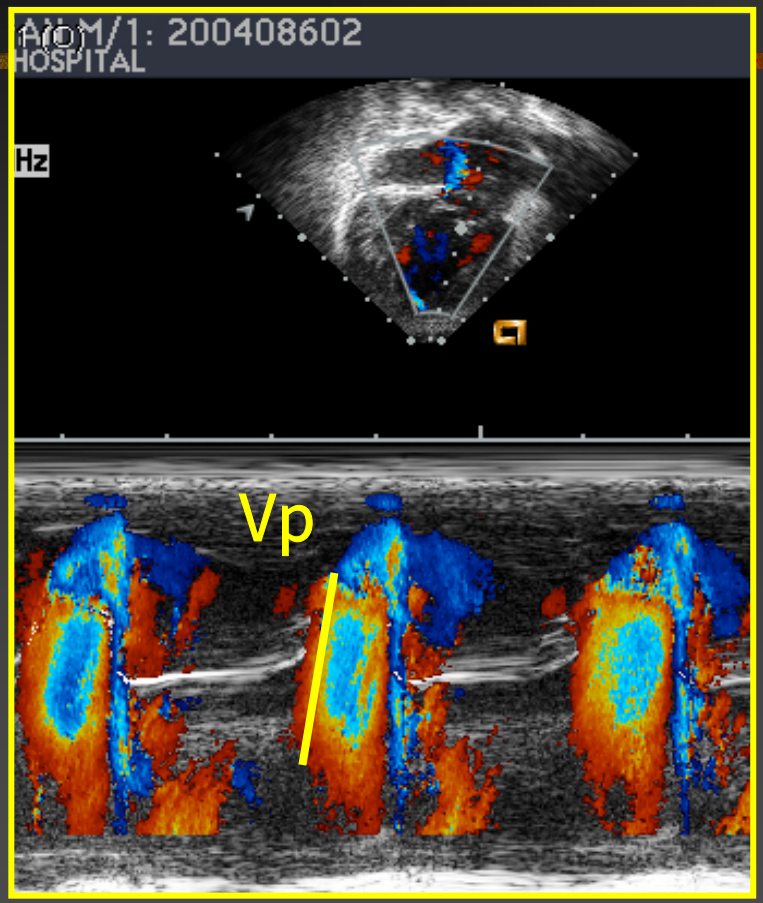


Transmitral & Transpulmonary Doppler Profile



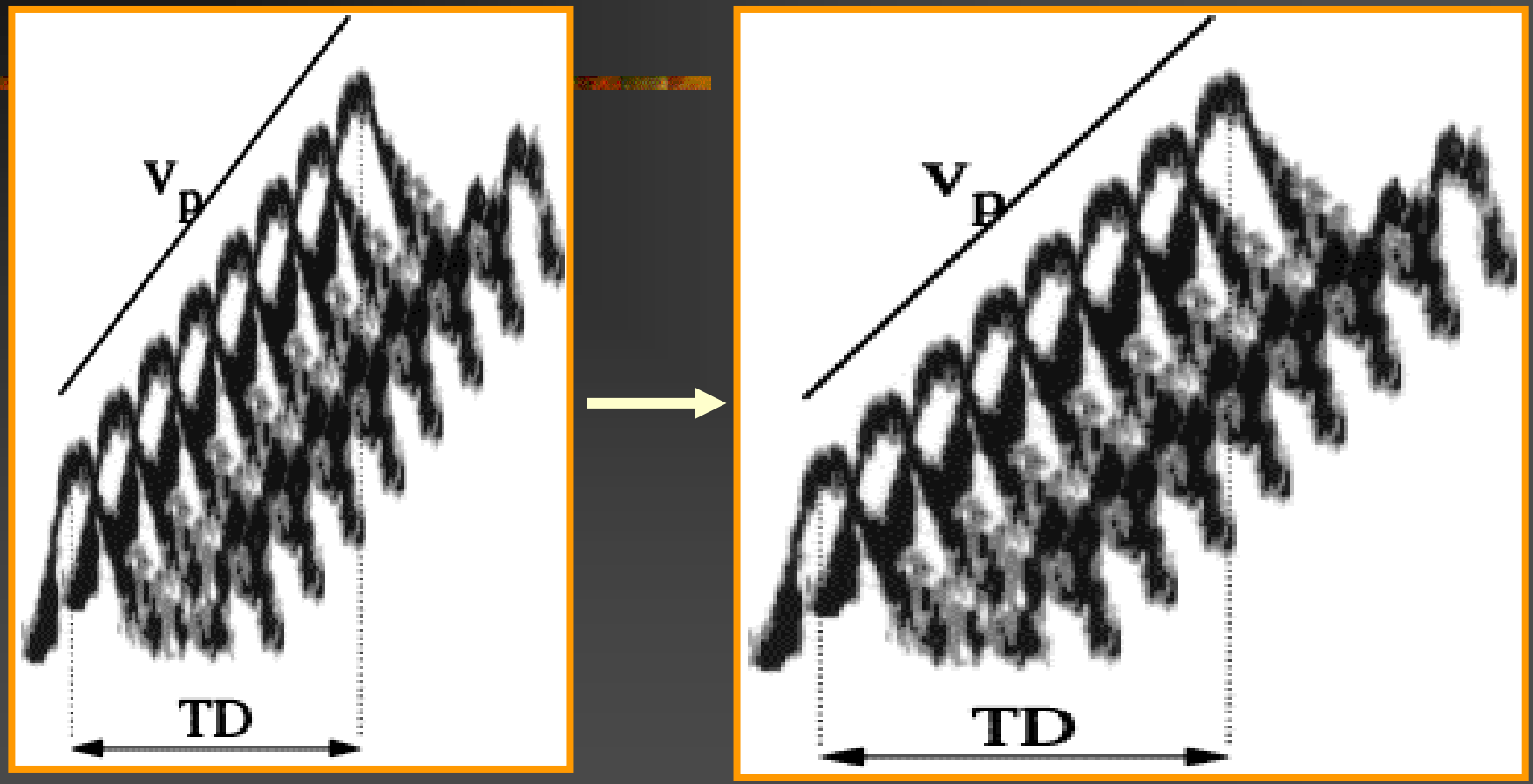
LVEDP :	N	N or ↑	↑↑↑
LA pr :	N	N or ↑	↑↑↑
Tau :	N	↑	↑↑
dP/dT_{min}	N	↓	↓↓

Color M-mode



- Propagation of flow during diastole from the atrium to the ventricle.
  - correlation with tau(time constant of relaxation)
  : useful index of LV relaxation.
  (preload independent)

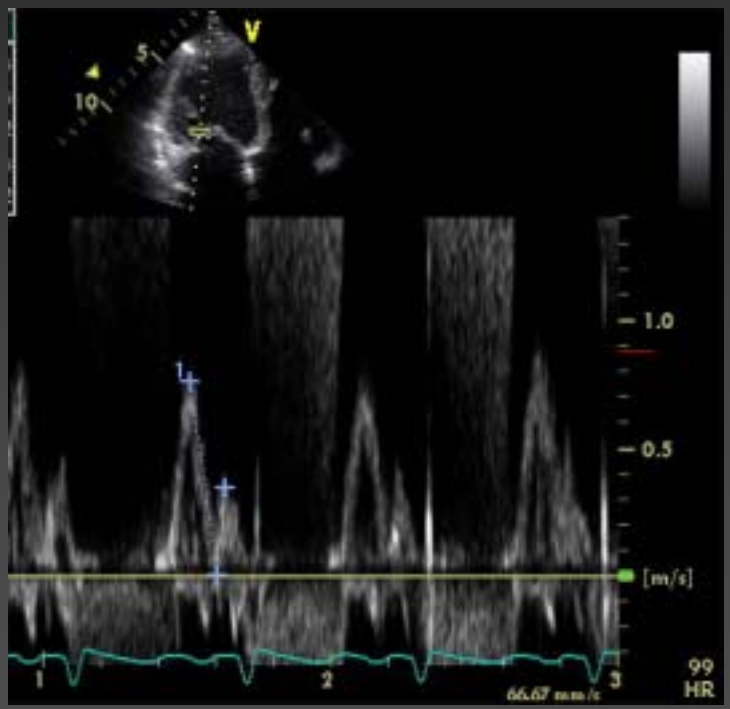
• Vp; slope of the first aliasing velocity during early filling



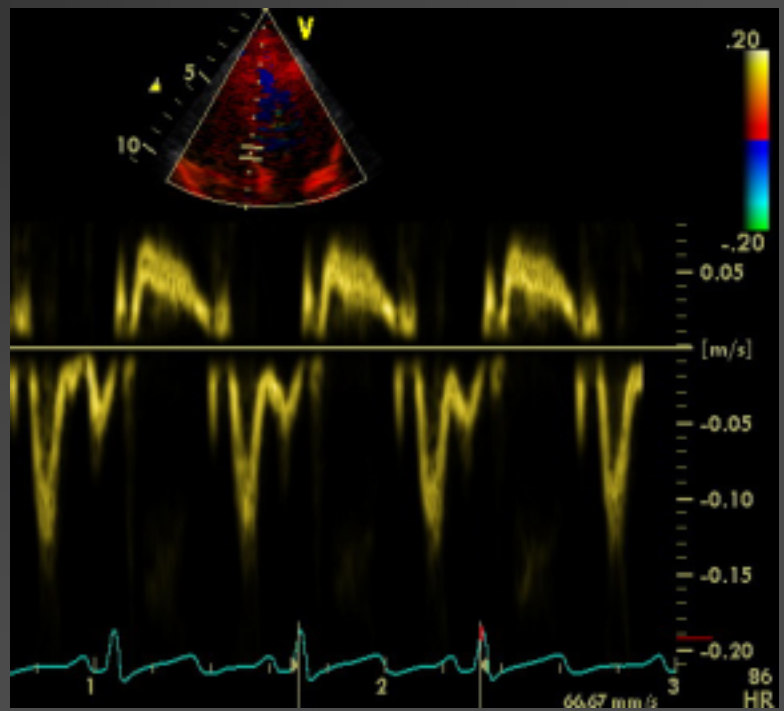
time delay **(TD)** of the peak E velocity from mitral tips to the apex.

Tissue Doppler Imaging

- Conventional Doppler
  ; measure velocity of RBC
- Tissue Doppler
  ; measure velocity of myocardial tissue



Blood: Mitral Flow



Tissue: MV Ring Motion

Strain & Strain Rate

: emerging technique

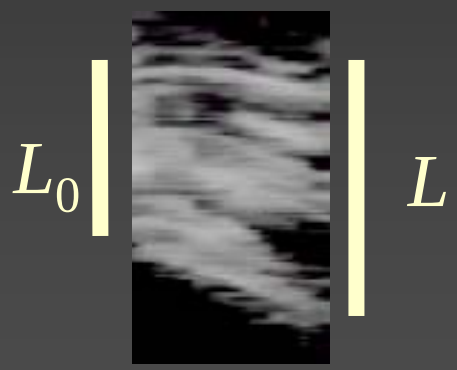
for assessing

syst. & diast. Function.

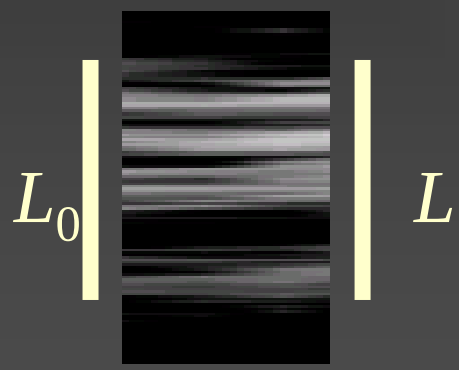
"Strain": deformation

$$S = \frac{L - L_0}{L_0}$$

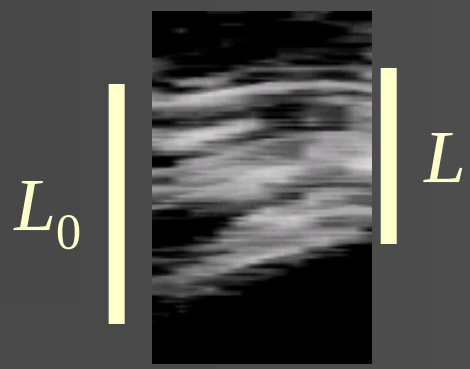
S = +25%



S = 0%



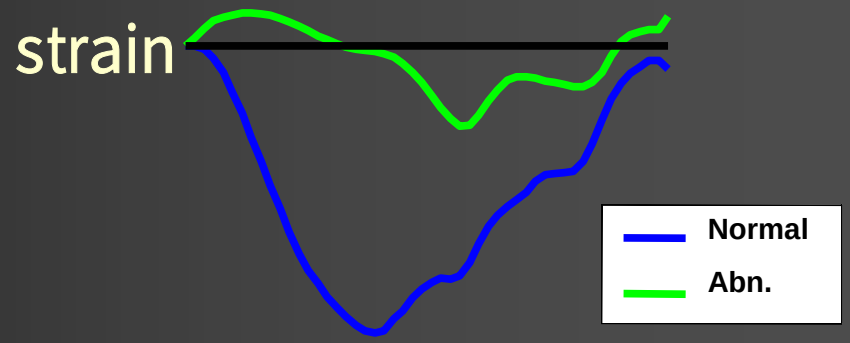
S = -25%



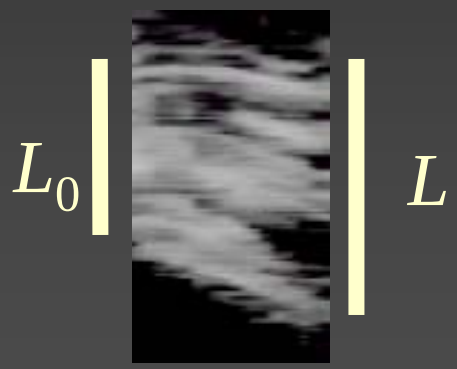
-> fractional change from original dimension
: lengthening or shortening.

"Strain": deformation

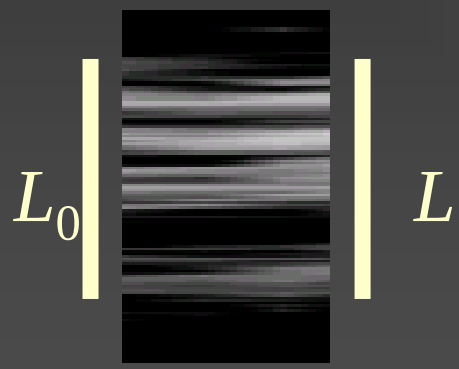
$$S = \frac{L - L_0}{L_0}$$



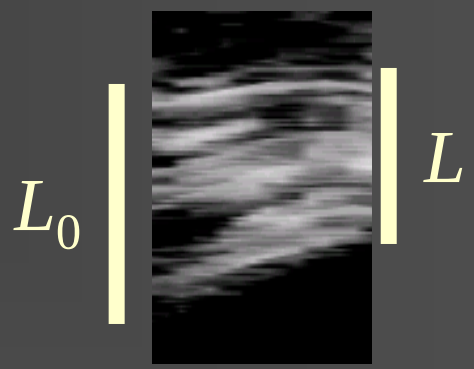
S = +25%



S = 0%



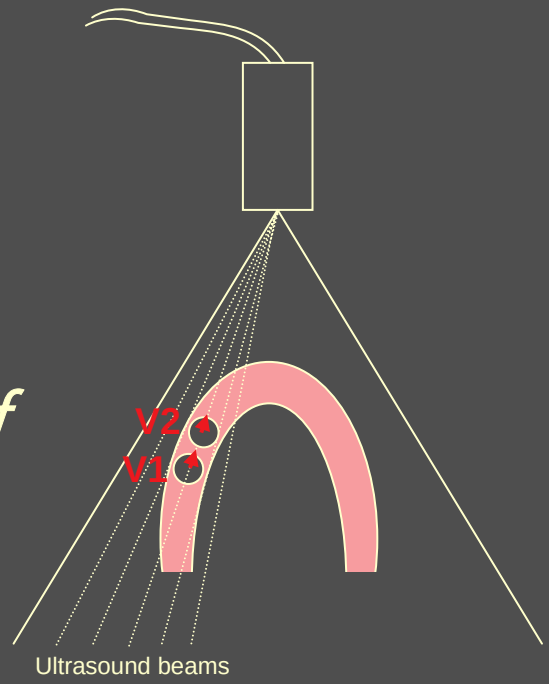
S = -25%



-> fractional change from original dimension
: lengthening or shortening.

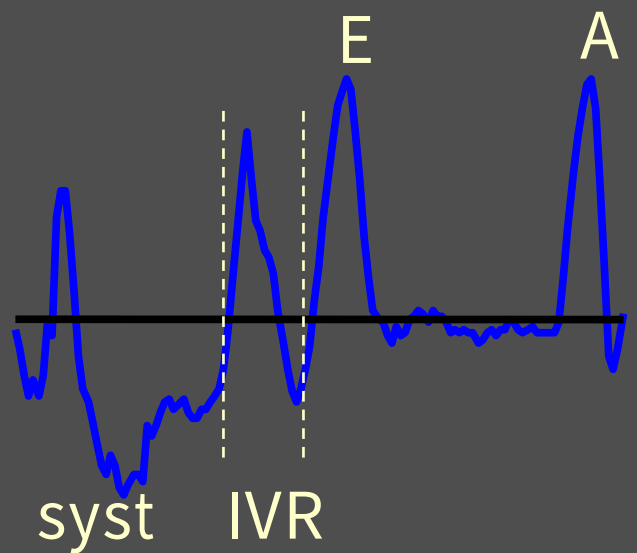
Strain Rate: rate of deformation

=> Quantitative assessment of regional myocardial function.



$$\textbf{Strain Rate} = \frac{V_2 - V_1}{d}$$

Strain Rate: rate of deformation



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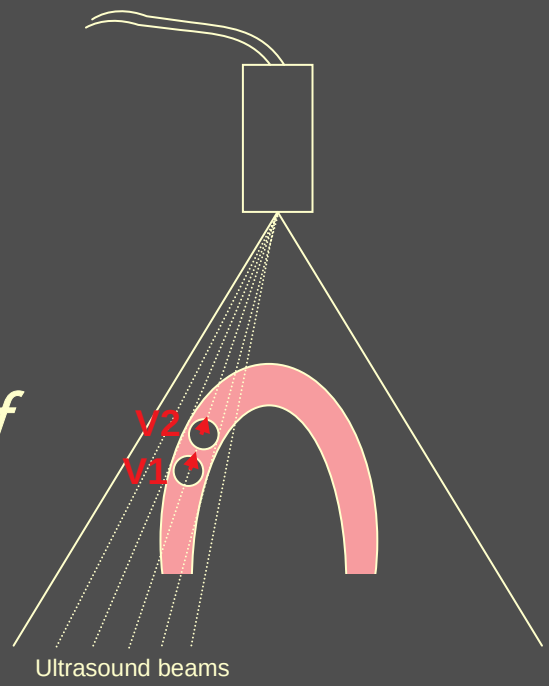


$$\textbf{Strain Rate} = \frac{V_2 - V_1}{d}$$

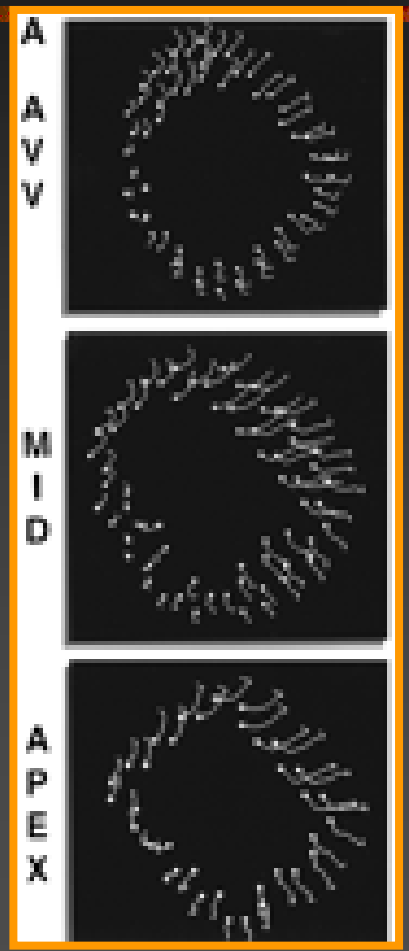
Left Atrial Volume

- LA is exposed to LV Pr.
  -> LA increases with decreased LV compliance

- LA Vol
  -> reflects the severity of diast. Dysfunction.
  -> usefual index of cardiovascular risk.

J Am Coll Cardiol 2005;45:87-92

MRI Tissue Tagging



Dots; ES position
Tails: diast. motion

To know the regional diast. Strain & wall motion,

In normal infants,
Diastolic movement : not homogeneous

=> Understanding of DD with CHD.

Circulation 2000;102:218-24

Brain Natriuretic Peptide

- BNP

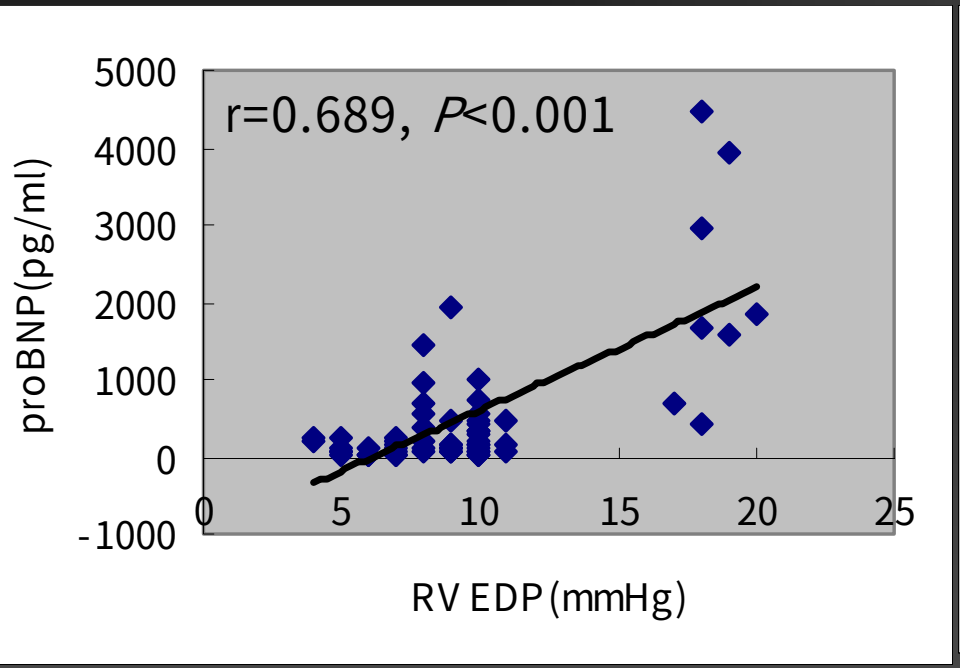
  : ass. with LVH, IVRT. LVEDP.

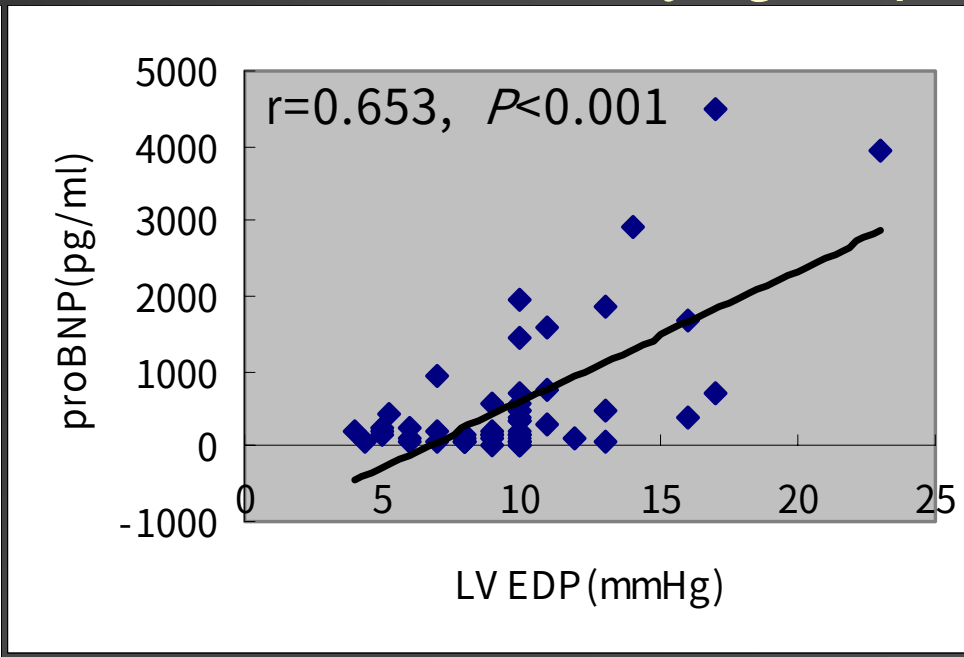
  ➔ used to diagnose of Diast. Dysfunction.

Eur J Heart Fail 2005;7:75-9

BNP & RV(LV)EDP

Sejong Hosp.





RVEDP<8: 133.2 pg/ml
RVEDP>9: 312.8 pg/ml
(*P*<0.001)

LVEDP<8: 133 pg/ml
LVEDP>9: 329.6 pg/ml
(*P*<0.001)

Diastolic Dysfunction in CHD

Aortic Stenosis

- Pr.- overloading due to AS
  => vent. Hypertrophy & remodelling
  => abn. Early diastolic relaxation & filling
  in spite of preserved syst. Function.
- Mech
  : myocardial collagen was increased.
  → myocardial fibrosis ↑

AS & AR on LV Diastolic Function

- Assessing diast. Function in AV disease(n=69)
  ; Diast. Dysfunction in 50% (AS),
  in 91% (AR)
  - normal syst. Function.

- Evaluation of tau, Kc, Km (stiffness constant)
  -> active relaxation ; impaired

  ; compensatory mech(hypertrophy)
  → impair diast. Function.

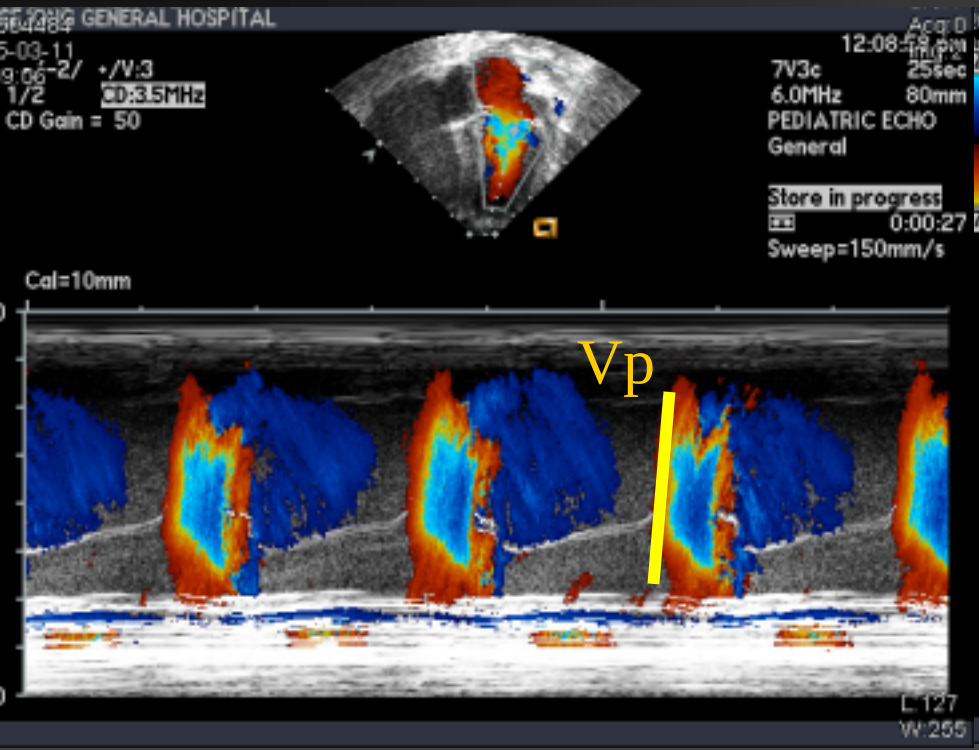
- DD precedes the reduction of syst. perfomance.

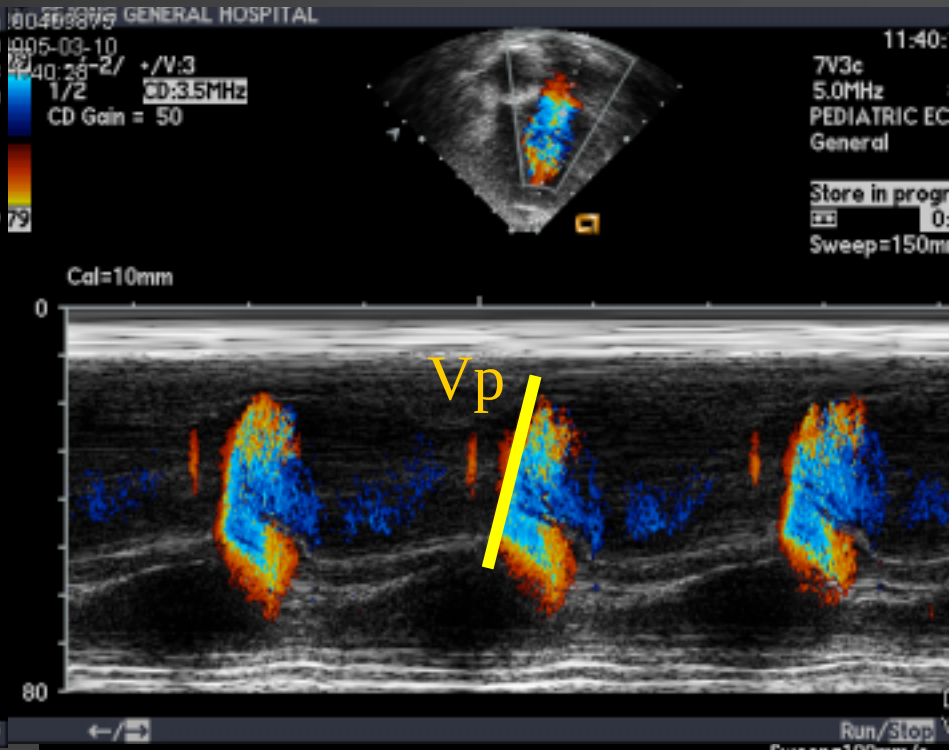
Am J Cardiol 1992;69:927-34

Coarctation

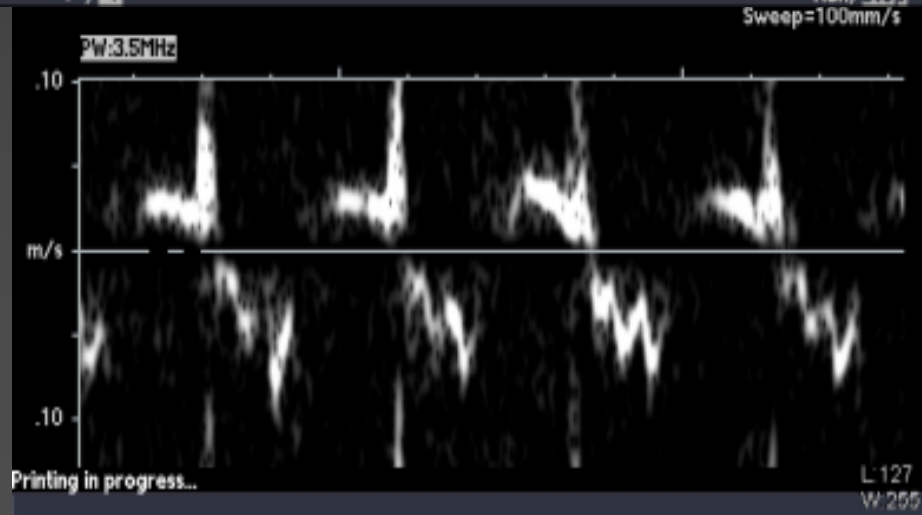
Normal

Coa with LVH





Impaired relaxation ⇐



Coarctation

- Increased afterload to LV
  -> vent. Wall tension ↑
  → LVH → LVEDP → LA pr. ↑
  ➔ Diast. Dysfunction.

#. Tau(time constant of relax)
  chamber stiffness constant
  Myocardial stiffness constant.

- Tx; afterload reducing agent
  (ACE inhibitor, vasodilator)

Tetralogy of Fallot

- Some s/p TOF pts.
  -> low CO, raised CVP,
  prolonged effusions or ascites,
  prolonged ventilator care & inotropic support.
  (in preserved bivent. Syst. Function)
  ➔ due to abnormalities of RV diast. Function
  (circulation. 1995)

#. Restrictive RV.
→chacterized by antegrade diast. Pul. Flow.
; RV is restrictive at end diast.
→ acting as a conduit bet. RA & PA. du. Atrial syst.

- Restrictive RV

; limted EDV,

#. Antegrade diast. Pul flow

→shorten duration of PR,

contribution to pul. Forward Flow & CO.

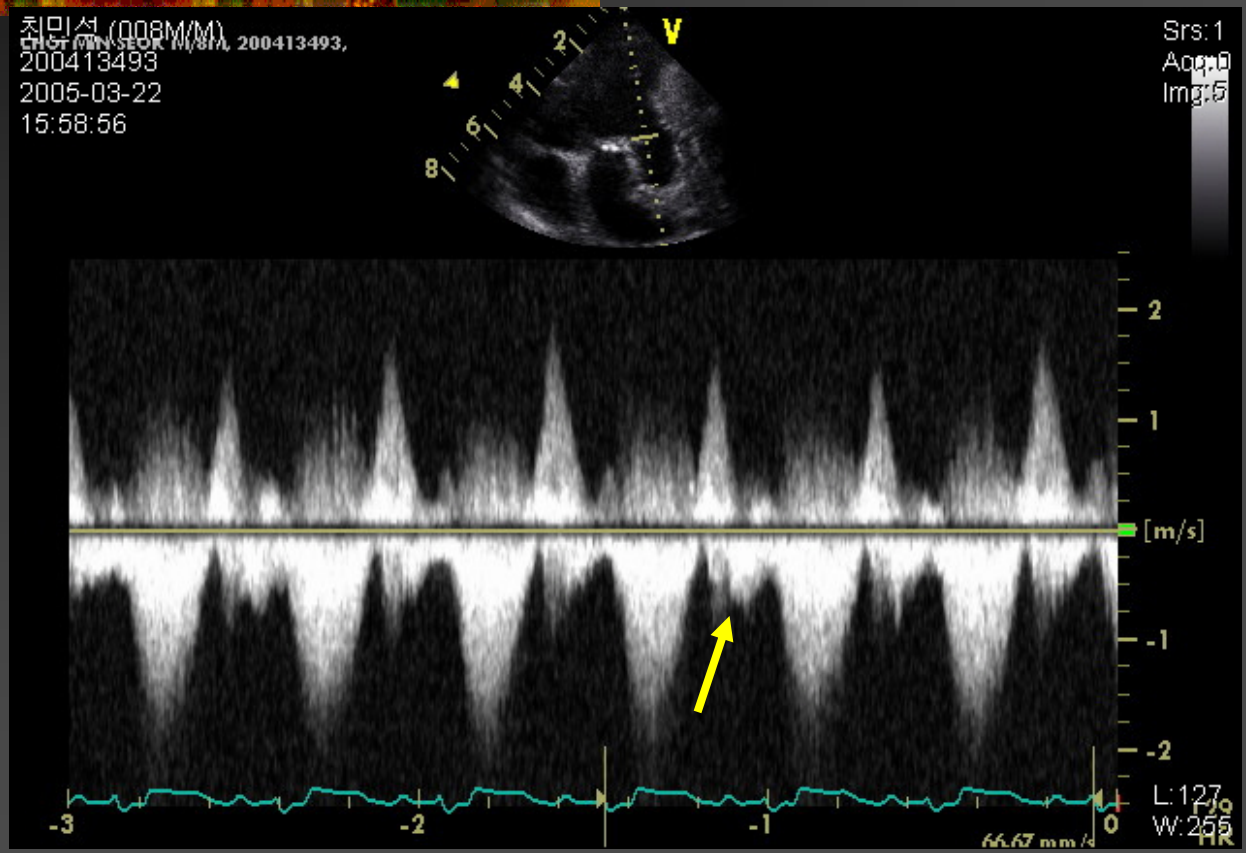
-> less cardiomegaly,

Exercise tolerance.↑

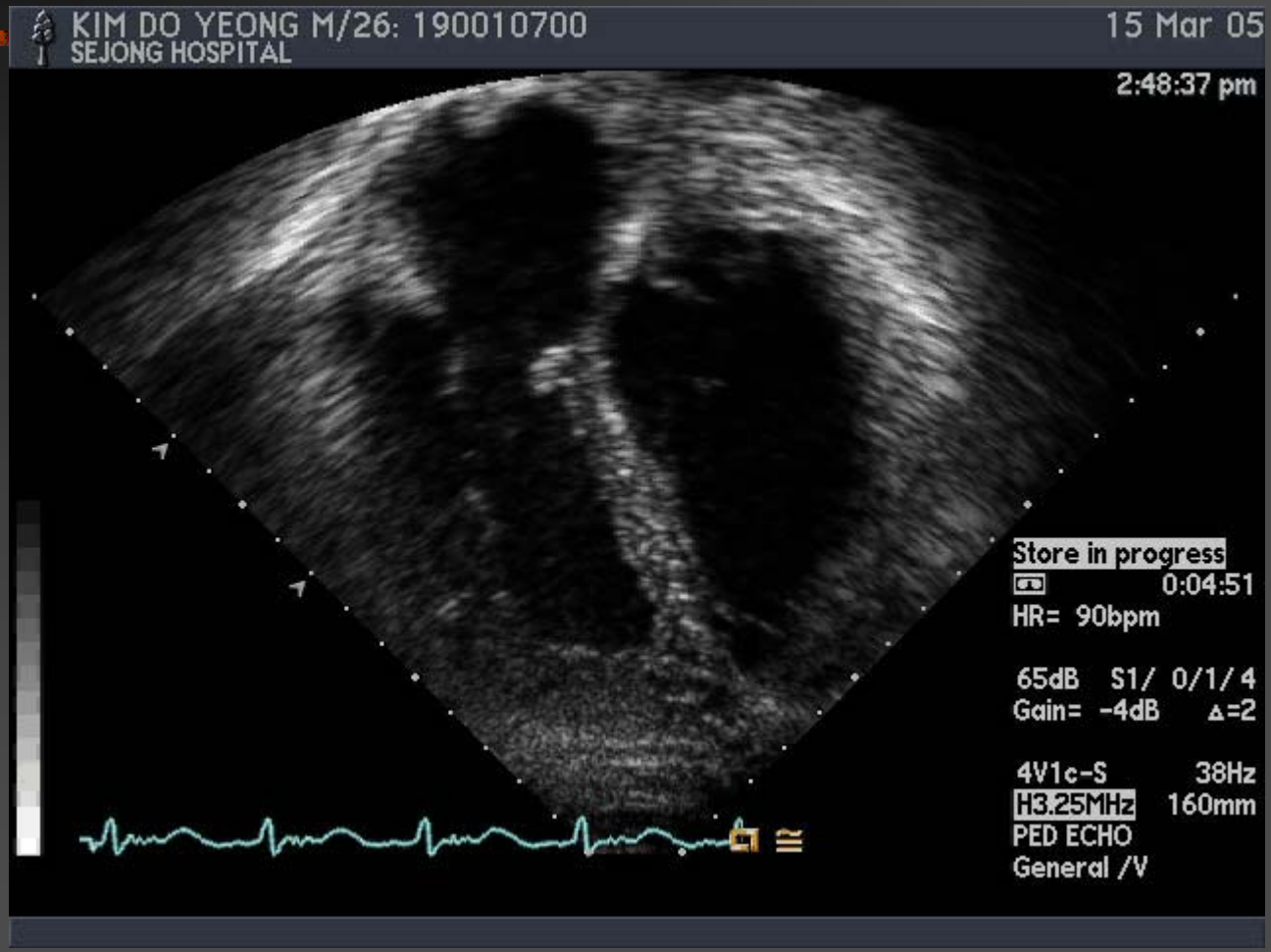
#. Maintenance of sinus rhythm

; important in restrictive RV.

Antegrade Diast. Pulmonary flow



S/P TOF (M/26)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SEJONG HOSPITAL
15 Mar 05
2:48:37 pm
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0:04:51
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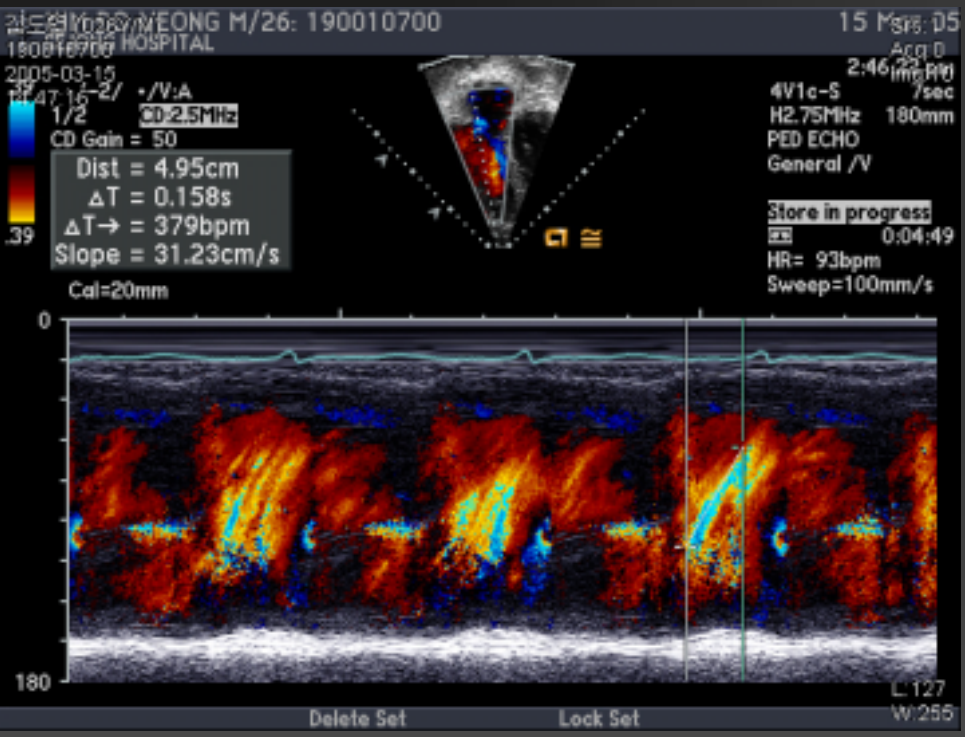
Gain= -4dB Δ=2
4V1c-S 38Hz
H3.25MHz 160mm
PED ECHO
General /V



Impaired Relaxation

Ebstein's Anomaly

- a - RV dilatation
- RV dysplasia
  - Fibrosis in RV ↑
  - myocardial fiber ↓
  - thinning of RV wall

→ RV syst. Excursion ↓
Prolonged relaxation

↓

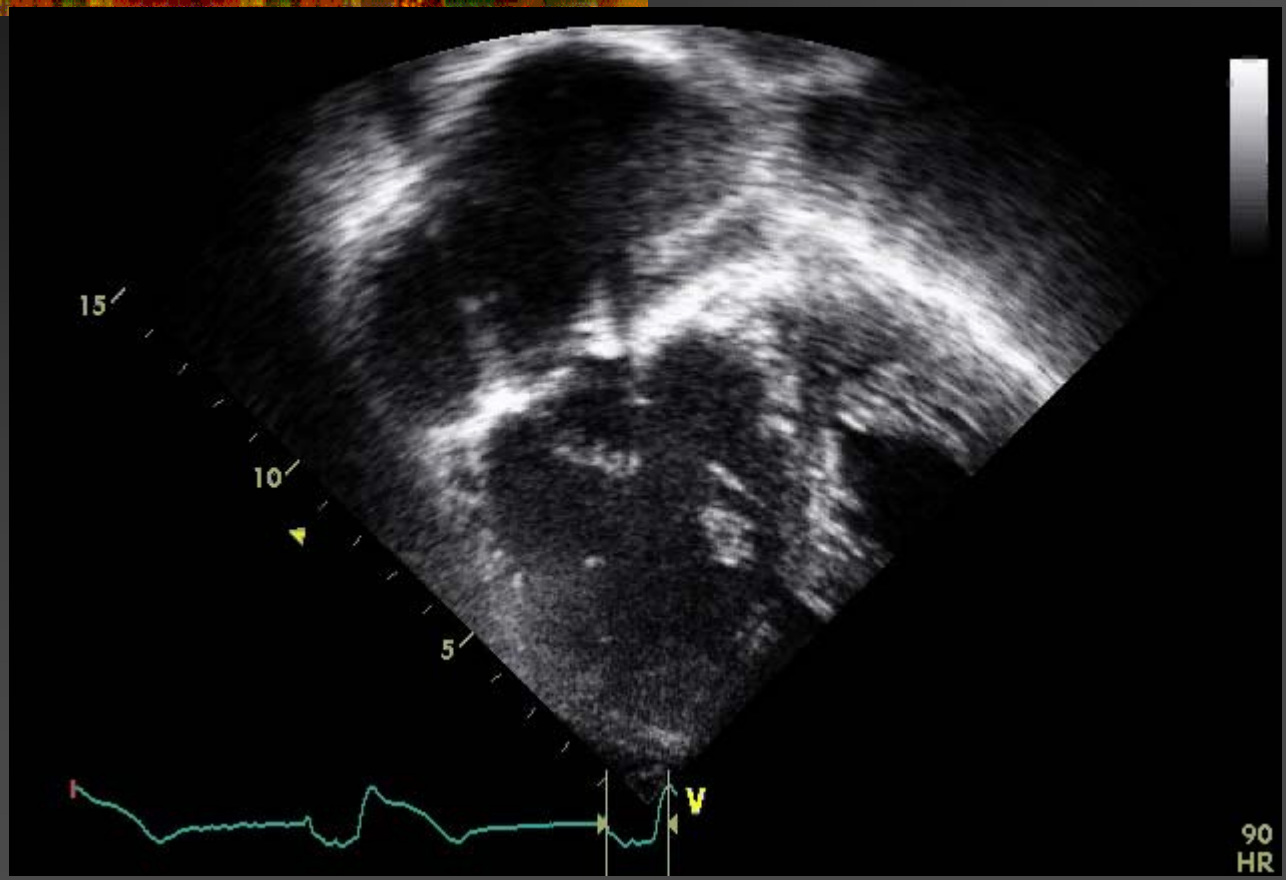
Syst. & Diast dysfunction (RV)

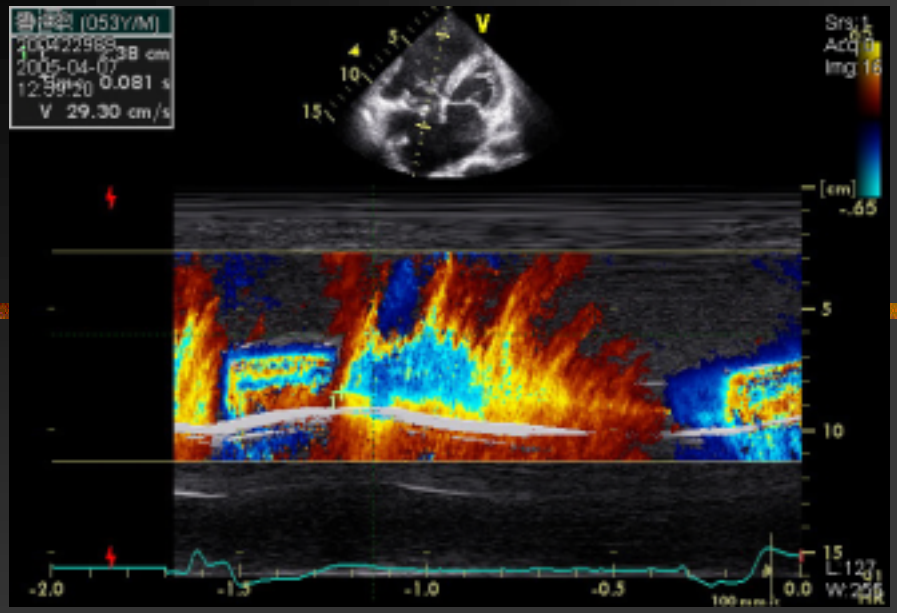
LV diast. dysfunction in Ebstein's Anomaly

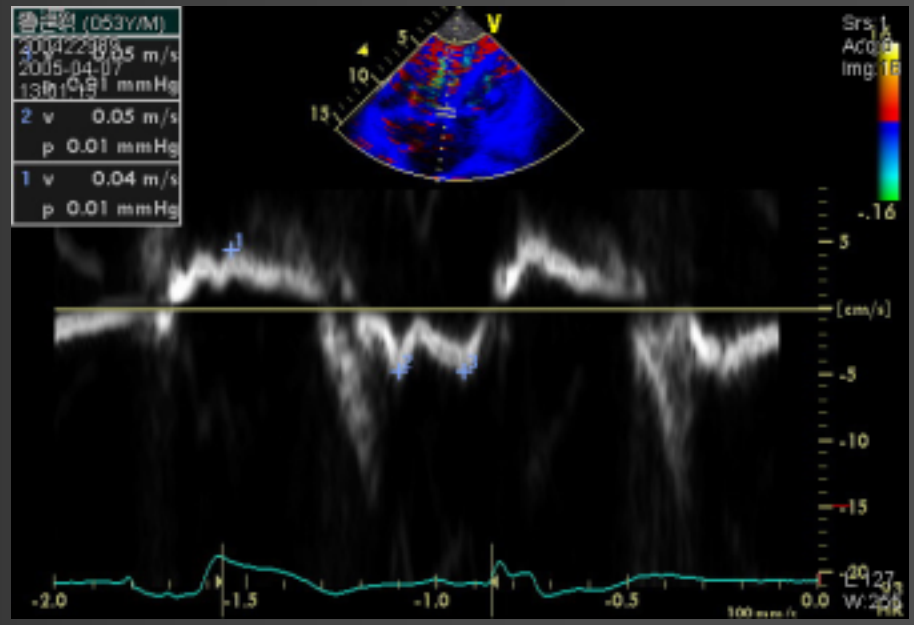
Evaluated by E/A ↓
IVRT ↑
DT ↑

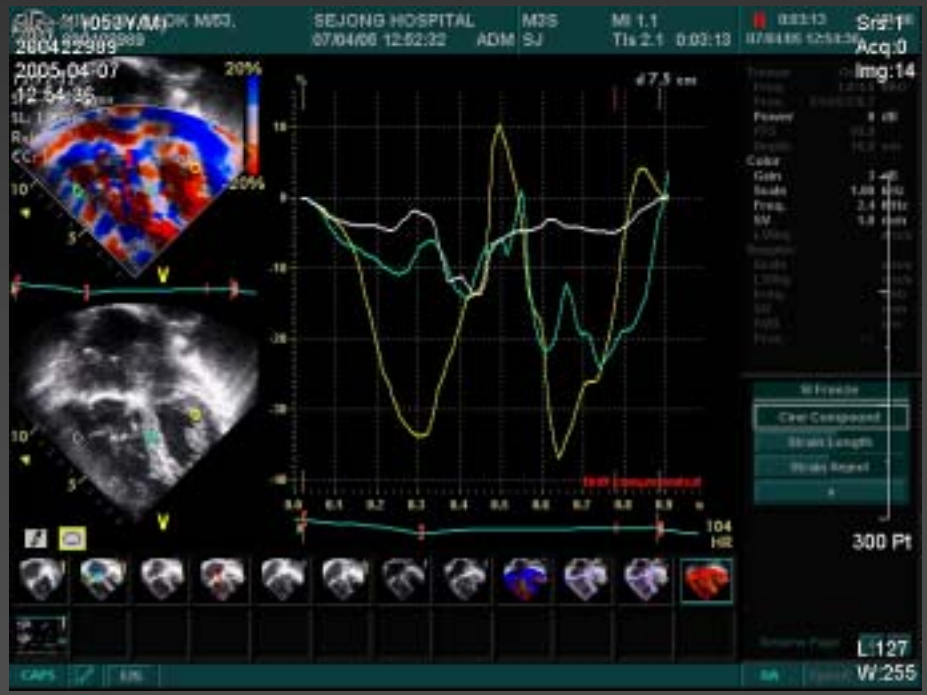
- Geometric change by RV Vol. Overload
  → abn. LV filling
- Fibrosis in LV wall & septum

Ebstein's Anomaly








SEJONG HOSPITAL
2005-04-07
12:54:36
300 Pt
L:127
W:255


SEJONG HOSPITAL
2005-04-07
12:56:43
300 Pt
L:127
W:255

Univentricle

- *Rudimentary chamber*
  -> cause regional wall motion abn.
  -> dysynchronous contraction of main vent.
  -> impaired relaxation & diast. Filling

- *Persistent vol. overload*
  -> vent. Dilatation & hypertrophy
  -> impaired relaxation & diast. Filling

- *Impaired Calcium cycling in UVH*

(suspicious)

: Ca^{++} release & reuptake by S.R.

-> important mech. For contraction , relaxation.

-> future incentive for pharmacologic Tx.

Pediatr Res 2003;54:885-91

Fontan Procedure

- Chronic vol. overload state
  -> Fontan : acute vol-reduction
  -> rapidly decreasing EDV
  -> diminished cavity & persistence of increased m. mass

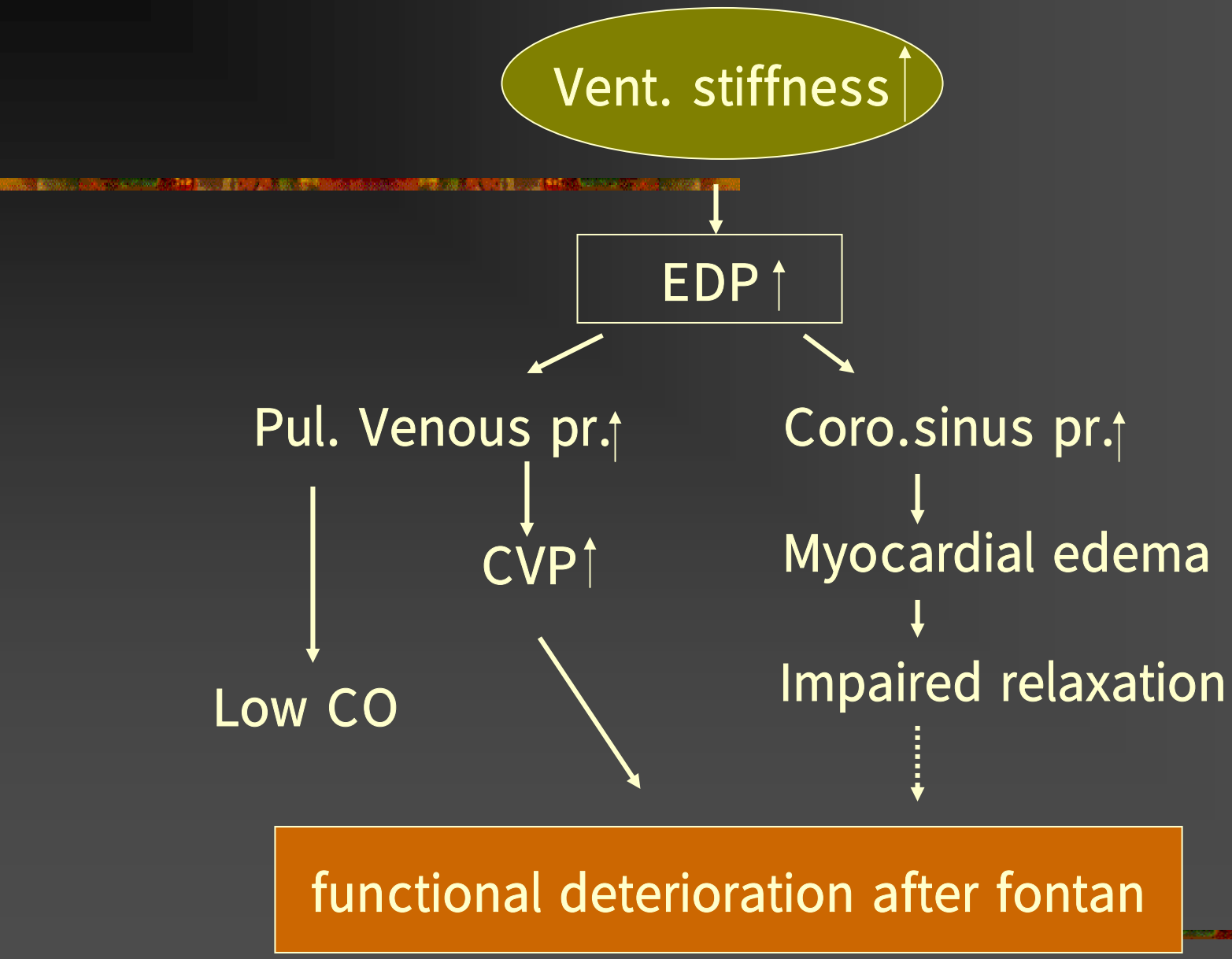
  ➔ wall thickness ↑ & mass/vol ↑
  ➔ Acute change in vent. Geometry
  (inappropriate hypertrophy)

Diastolic dysfunction after Fontan

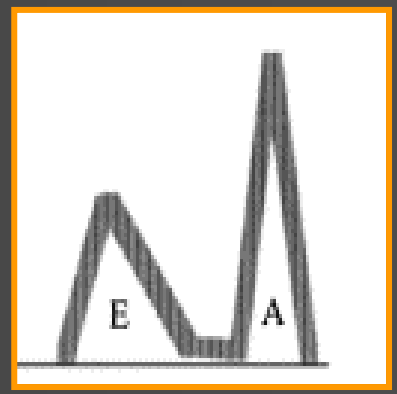
- s/p Fontan
  - regression of hypertrophy : 1-3 yrs after op.
    → persistence of impaired relaxation.

- Decreased vent. Compliance.
  by. 1. Synthesis of collagen → myocardial fibrosis↑
  2. Reduced filling of vent.
  3. SVR↑ after fontan.

Heart 2000;83:420-4


Vent. stiffness ↑
EDP ↑
Pul. Venous pr.↑
Coro.sinus pr.↑
CVP↑
Myocardial edema
Low CO
Impaired relaxation
functional deterioration after fontan

- *Impaired relaxation after fontan*



-> Early vent. Filling ↓

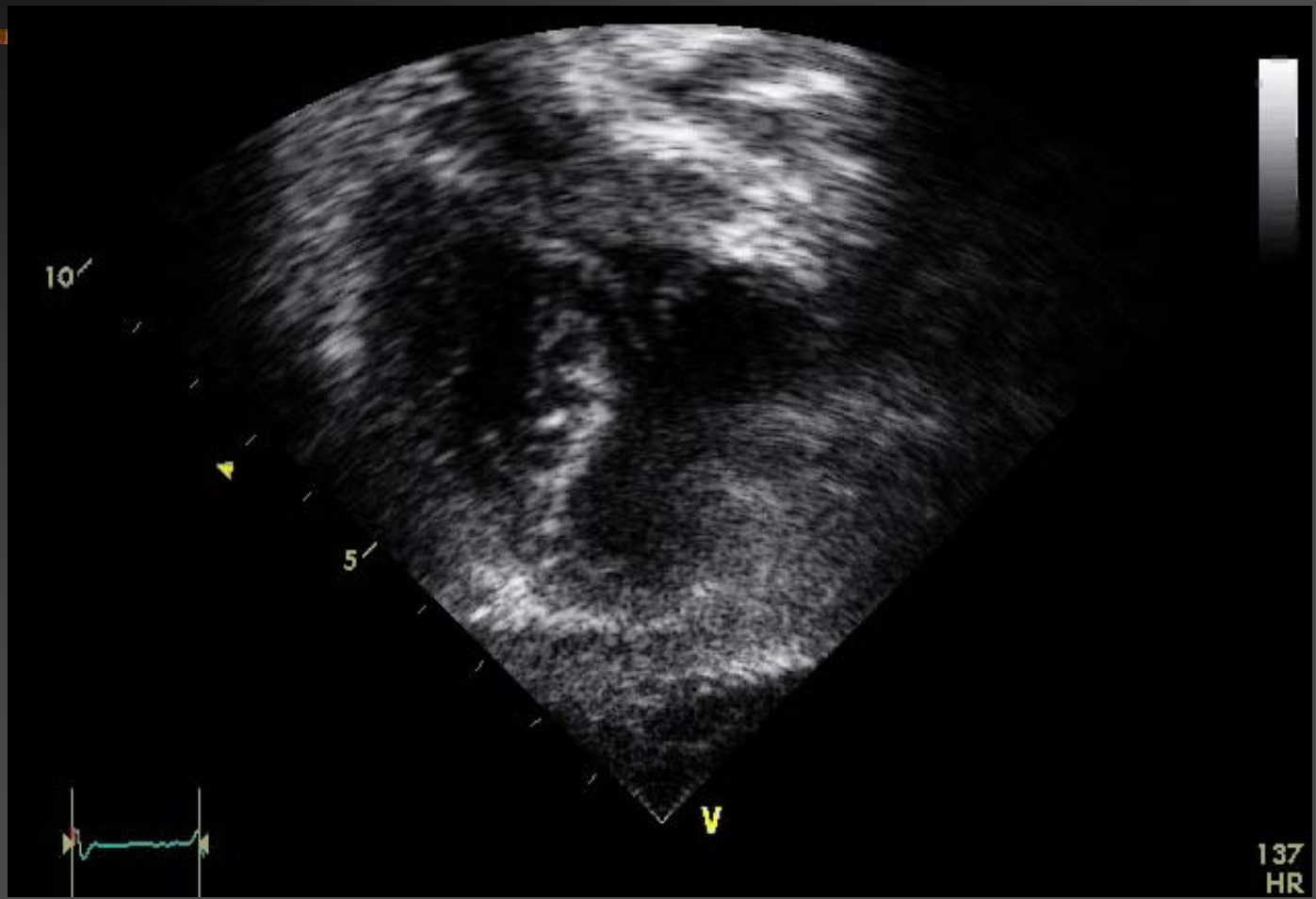
-> Atrial contribution to vent. Filling(32%)

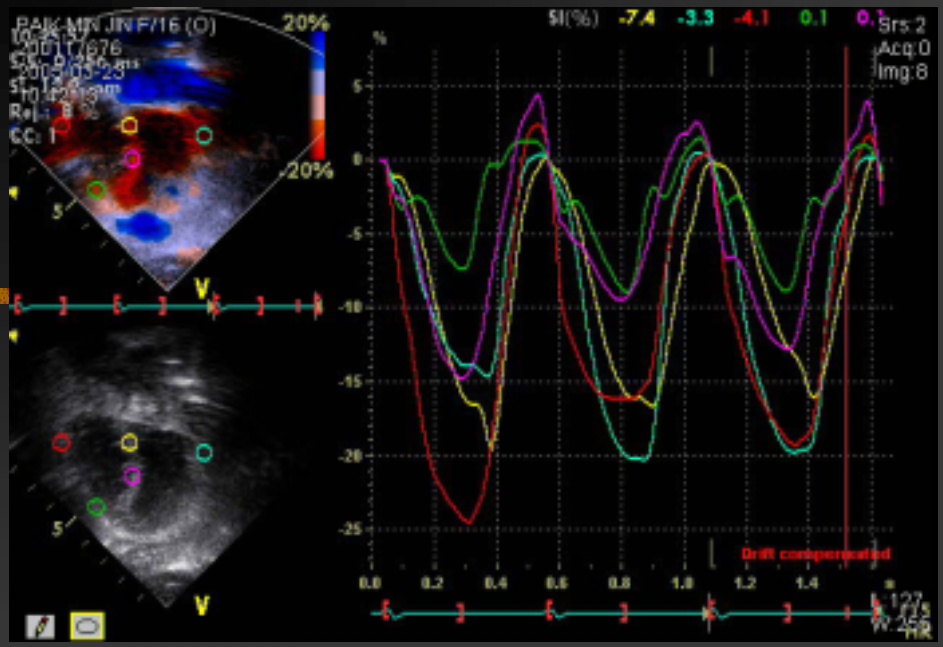
➔ At. Kick dependent vent. filling

=➔ *importance of sinus rhythm,*
of tachycardia prevention.

Lt. Isomerism, Common atrium, C-AVSD (pre-Fontan state)

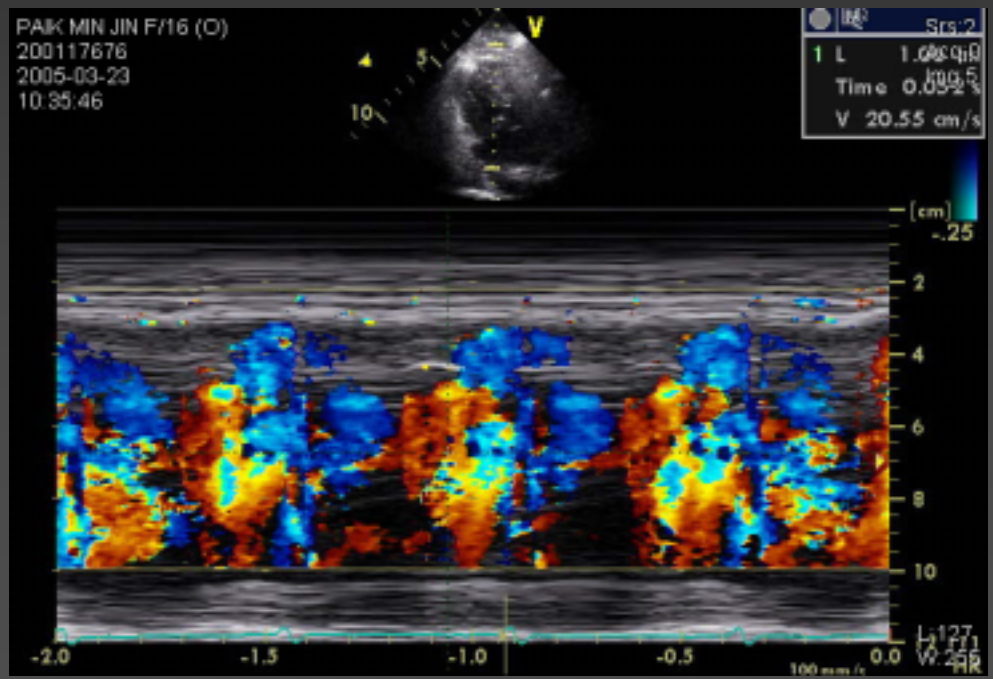
S/p Fontan

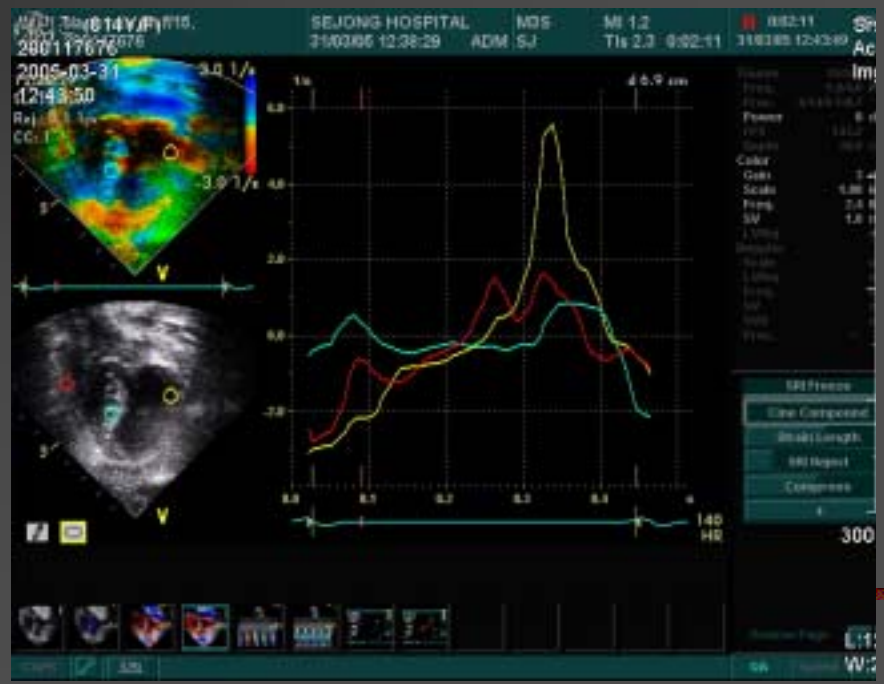


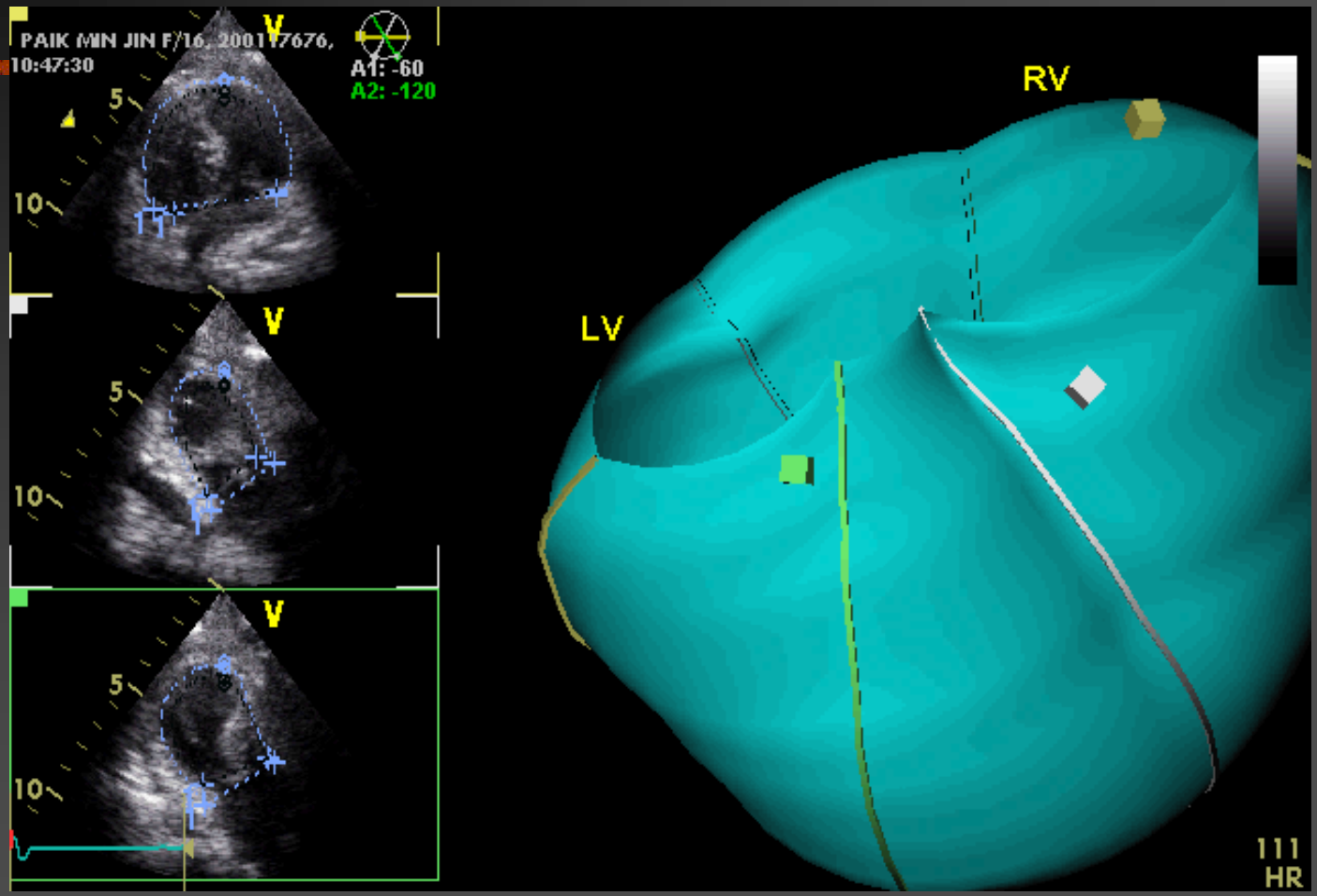


Preserved syst. Function

Impaired diast. function






PAIK MIN JIN F/16, 2001/7676,
10:47:30
A1: -60
A2: -120
5
10
V
RV
LV
111
HR

Post-op Changes in Vent. Geometry

Wall thickness(cm)	Fontan	VSD	BCPS
Pre-op	0.93	0.99	1.15
post	1.42	1.25	1.27
(+)% change	*53%*	28%	9%

Cavity Vol.(ml)	Fontan	VSD	BCPS
Pre-op	52	46	58
post	27.4	29.8	44
(-)% change	*46%*	32%	24%

- Different vent. Filling path.
  : aid of pul.pumping chamber

- In Fontan, vent.filling force
  ➔ *Diast. Function (suction force).*

(Ann Thorac Surg 1995;60:1267-74)

Hypertrophic Cardiomyopathy

- Histology
  - myocardial fibrosis,
  - Cardiac m. disorganization → stiffness ↑
  - myocyte hypertrophy

→ Diast. Dysfunction

  - abn. Calcium meta. → Impaired relaxation

IVRT ↑
reduced max. velocity du.early diast.
E/A ≤ 1
DT ↑

Management

- Modern management
  - normalization of hemodynamics.
  - improvement of Symptoms.

#. Pathophysiologic Aspects
  - neuroendocrine stimulation
  - myocyte remodelling
  - conn. Tissue/ myocyte interactions
  - cellular energetics.

Pharmacologic Tx

- *Aim*
  - congestive state(preload)
  - control of afterload(B.P)
  - normal sinus rhythm
  - tachycardia prevention
  - Ischemia prevention

Consideration of pathophysiologic aspect.

Inotropics (with caution)

- may be benefical in short-term tx.
  (accompanying SHF)
- generally not used in DHF.
  -> worsen DHF
  : Digitalis, Dopa => intracellular Ca.↑
  => diast. Ca. overload.
  ➔ promote diast. Dysfunction

- *Diuretics* (with caution)
  - Reduce pul. Congestion in DHF
  - To avoid exessive diuresis
    (due to highly sensitive to vol. Change in DHF)
    => LV pr., Stroke vol., BP ↓

- *Beta - blockers*
  - HR ↓
  - O2 consumption ↓
  - BP ↓
  - diast. Filling time ↑

  - RAA ↓
  - endothelin ↓
  - vent.wall stress ↓
    ➔ reverse
    vent. remodelling

Neurohormonal Agent

- ACE inhibitor
  - afterload (vasodilation)
  - NE release
  - reverse fibrosis

- AT receptor antagonist
  - AT II : hypertrophy,
    aldo- release ,
    collagen synthesis

- Aldosterone antagonist
  - aldo -> collagen ↑
    -> fibrosis
    => Vent. Stiffness↑
    compliance↓
    ➔ Diast. dysfunction

Improve LV relaxation,
Reverse LV remodelling

- *Phosphodiesterase inhibitor*
  - afterload (vasodilating effect) ↓
  - Ca. reuptake by SR ↑
    => improve relaxation.

- *Calcium channel Blocker*
  - improve relaxation
    & symptomatic relief.

Future agent

- Calcium sensitizer
- Calcium channel antagonist
- Endothelin receptor antagonist
- Anti-inflammatory Tx
- Gene therapy
  - gene mutations in sarcomeric prot. In HCMP.
    => replacement of defective gene.

Conclusions

1. The importance of diastolic ventricular function in CHD has become more apparent with understanding of pathophysiology and deveolpment of diagnostic tool.

2. The truly effective therapy for DHF depends on gaining a clear understanding of basic mech. about diast. dysfuncion.

3. The treatment is directed at normalization of hemodynamics, at elimination of the factors causing diast. Dysfunction(eg, hypertrophy, fibrosis, ischemia).

4. Because the complexity in pediatrics relates to the timing and type surgery to correct structural heart disease, the management of DHF poses many challenges and require a comprehensive and integrative approach.