RESPIRATORY MANEUVERS IN ECHOCARDIOGRAPHY - CLINICAL APPLICATIONS -

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DURING ECHOCARDIOGRAPHIC EXAM, RESPIRATION INDUCES CYCLIC PHYSIOLOGICAL CHANGES OF INTRACARDIAC HAEMODYNAMICS

RELATED TO VARIATION IN

- INTRATHORACIC AND INTRAABDOMINAL PRESSURE
- SYSTEMIC AND PULMONARY VENOUS RETURN
- INTRAPERICARDIAL PRESSURE, PERICARDIAL CONSTRAINT
- INTERDEPENDENCE BETWEEN CARDIAC CHAMBERS

WITH INSPIRATION – INTRATHORACIC AND INTRA PERICARDIAL PRESSURES DECREASE ⬇

- THIS RESULTS IN **AUGMENTED** RV FILLING AND STROKE VOLUME
- AND A COMPENSATORY **DECREASE** IN LV STROKE VOLUME WHICH OCCURS IN EARLY INSPIRATION

WITH EXPIRATION – INTRATHORACIC AND INTRA PERICARDIAL PRESSURES INCREASE ⬆

- RESULTING IN MILD **DECREASE** IN RV DIASTOLIC FILLING
- AND A SUBSEQUENT **INCREASE** IN LV FILLING

THE IMPACT OF RESPIRATORY CYCLE

GENERAL ECHOCARDIOGRAPHIC DATA

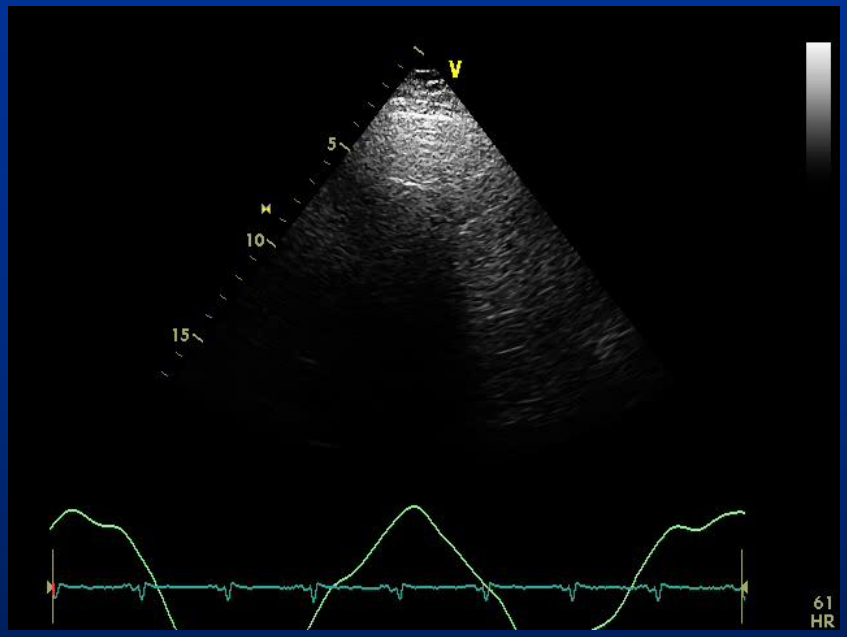
2 D – ECHO	• IMAGE QUALITY • MEASUREMENTS
DOPPLER	

ECHO EVALUATION OF HAEMODYNAMIC PARAMETERS

ECHO DIAGNOSIS OF C-V DISEASES

2 D – IMAGE QUALITY

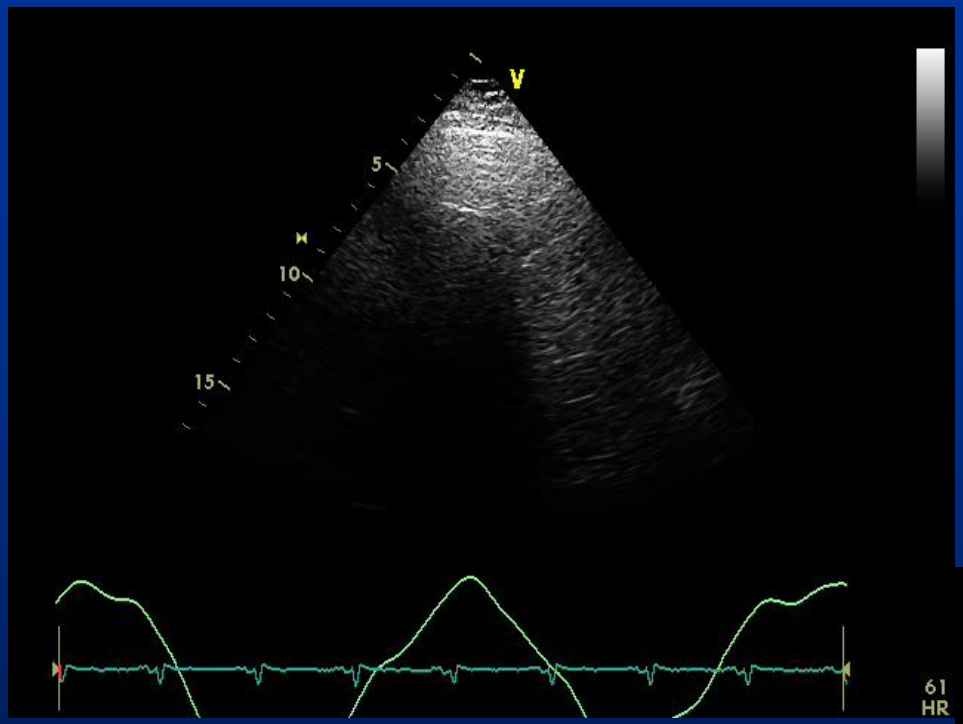
THE RESPIRATORY MOVEMENTS ARE REPRESENTED BY THE GREEN LINE



TT APICAL 4 CHAMBER VIEW DURING NORMAL RESPIRATION

DURING **INSPIRATION**
PULMONARY INTERFERENCE
DOES NOT ALLOW
THE VISUALISATION
OF CARDIAC STRUCTURE

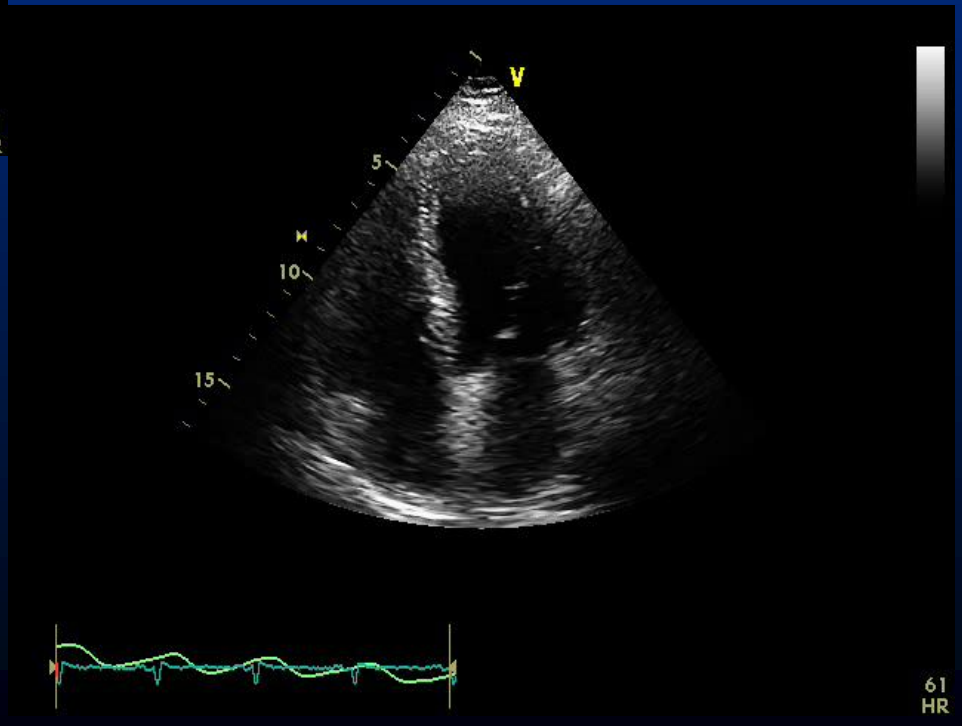
2 D – IMAGE QUALITY



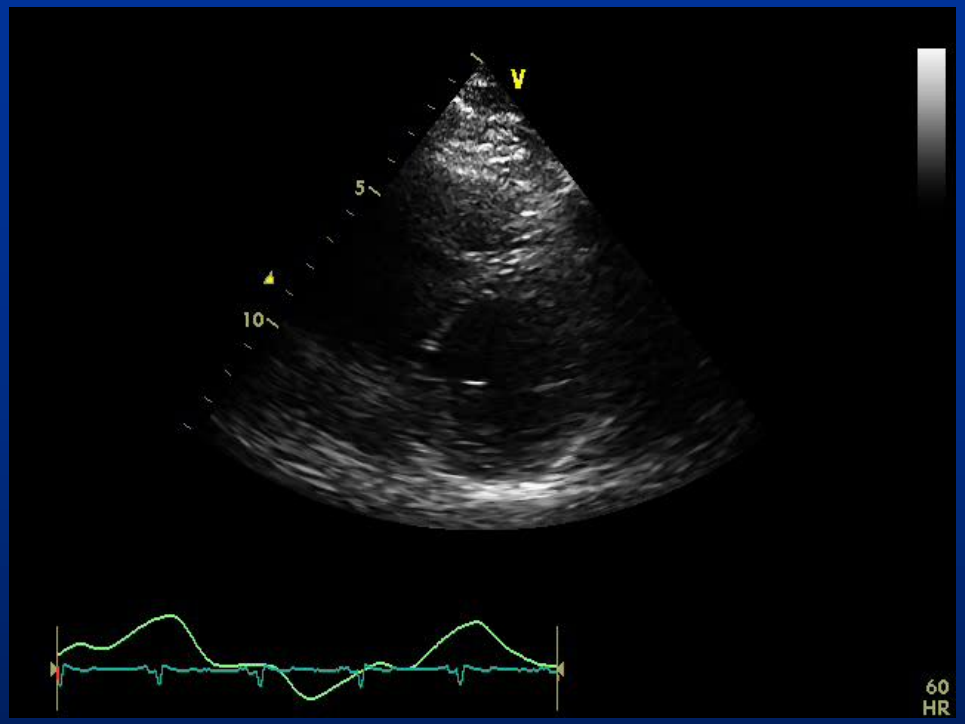
DURING **HELD END EXPIRATION**
(LUNG DEFLATION)
THERE IS A SIGNIFICANT
IMPROVEMENT IN THE QUALITY
OF ECHO IMAGE

TT APICAL 4 CHAMBER VIEW
DURING NORMAL RESPIRATION

DURING **INSPIRATION**
PULMONARY INTERFERENCE
DOES NOT ALLOW
THE VISUALISATION
OF CARDIAC STRUCTURE



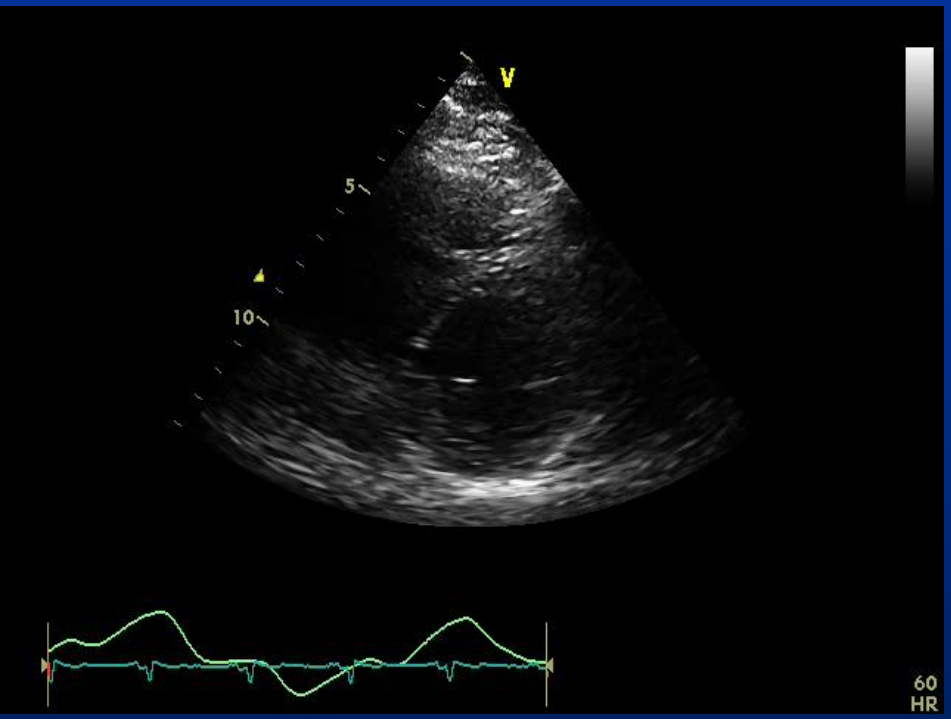
2 D – IMAGE QUALITY



TTA SHORT AXIS VIEW
DURING NORMAL RESPIRATION

DURING **INSPIRATION**
THE HEART MOVES MEDIALLY
THE EXCESSIVE TRANSLATIONAL
MOTION INTERFERES
WITH THE VISUALISATION
OF CARDIAC STRUCTURES

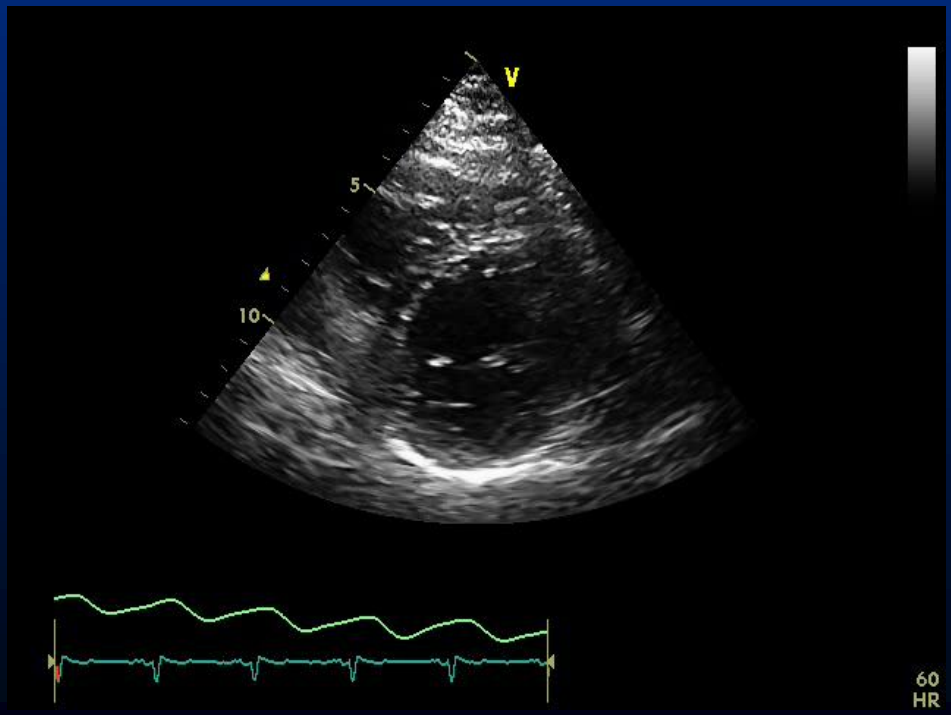
2 D – IMAGE QUALITY



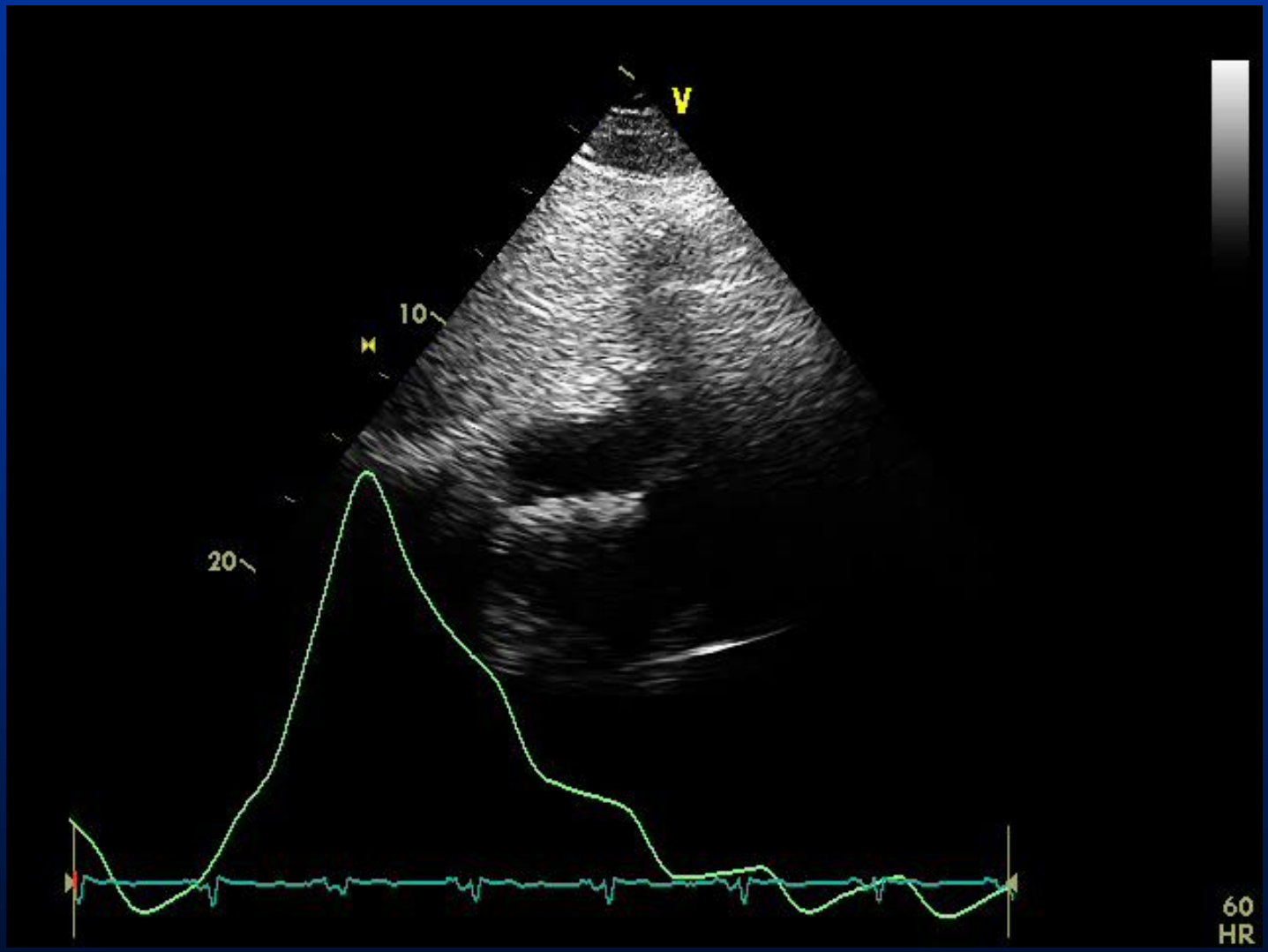
EXCESSIVE TRANSLATIONAL MOTION
CAN BE AVOIDED
BY ACQUIRING IMAGES
DURING **HELD END - EXPIRATION**

TTA SHORT AXIS VIEW
DURING NORMAL RESPIRATION

DURING **INSPIRATION**
THE HEART MOVES MEDIALLY
THE EXCESSIVE TRANSLATIONAL
MOTION INTERFERES
WITH THE VISUALISATION
OF CARDIAC STRUCTURES



2 D – IMAGE QUALITY



SUBCOSTAL VIEW

INSPIRATION BRINGS THE DIAPHRAGM DOWN
IMPROVING THE IMAGING OF THE HEART

2 D – MEASUREMENTS

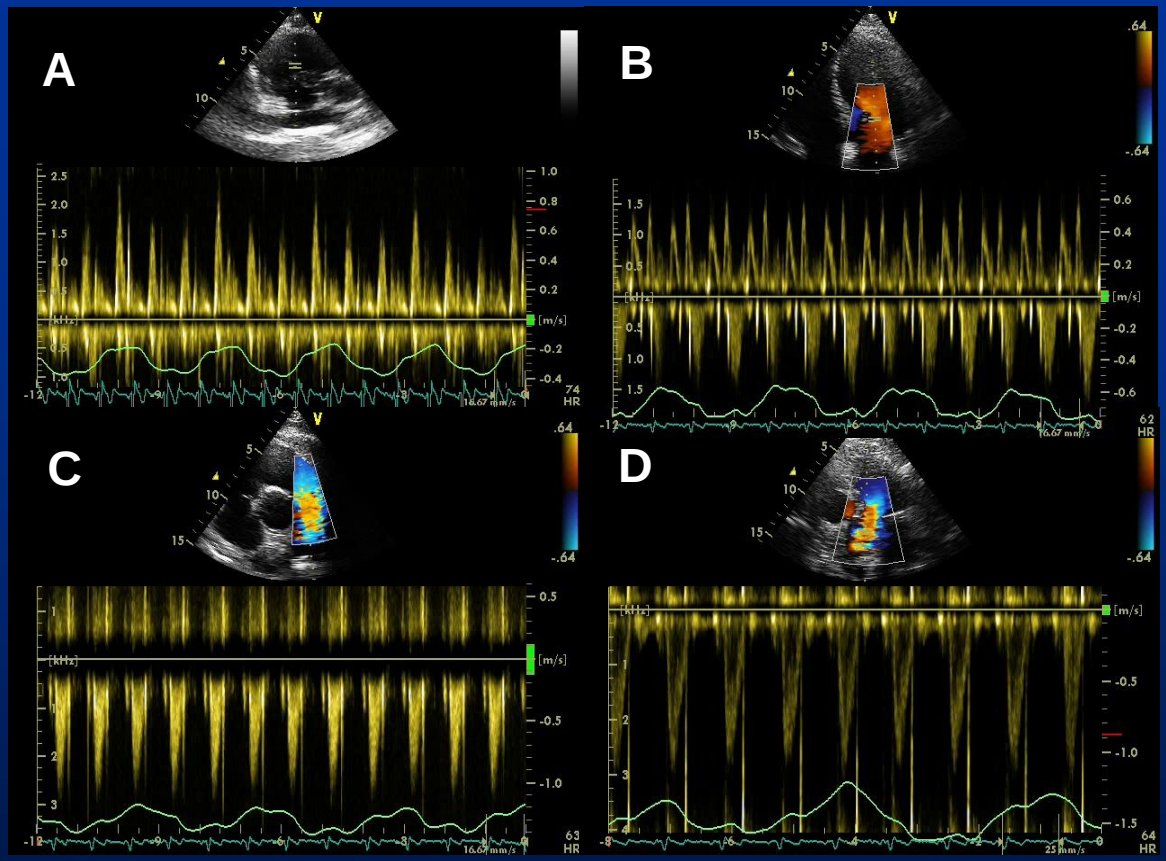
AN INSPIRATORY REDUCTION IN LV END DIASTOLIC DIMENSION ASSESSED BY M-MODE ECHO WAS FOUND IN NORMAL SUBJECTS

- THE INPIRATORY DIMENSIONS CAN BE SMALLER ALONG THE M-MODE CURSOR THAN THROUGH THE CENTER OF THE SHORT AXIS AREA BECAUSE OF **MEDIALLY MOVEMENT** OF THE HEART

- AN INSPIRATORY DECREASE OF LV END DIASTOLIC VOLUME AS A CONSEQUENCE OF **PRELOAD REDUCTION** AND **INCREASED AFTERLOAD**

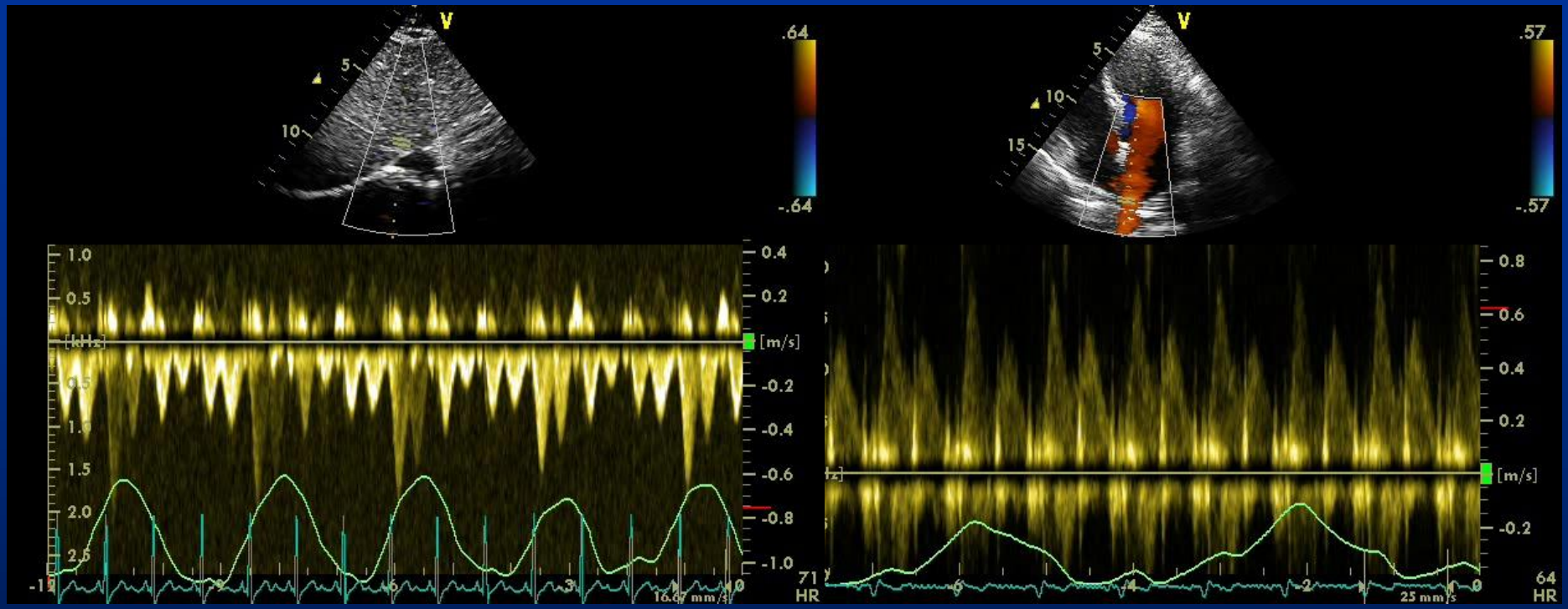
BRENNER J.L, CIRCULATION, 1978
ANDERSEN K., CIRCULATION, 1984

DOPPLER – FLOW VELOCITY PATTERN



PHYSIOLOGICAL VARIATION OF THE VELOCITY ACROSS THE TRICUSPID VALVE (25% OR LESS), MITRAL V (15%), PULMONARY AND AORTIC V (LESS THAN 10%) DURING QUIET RESPIRATION IN A NORMAL HEART

DOPPLER – FLOW VELOCITY PATTERN

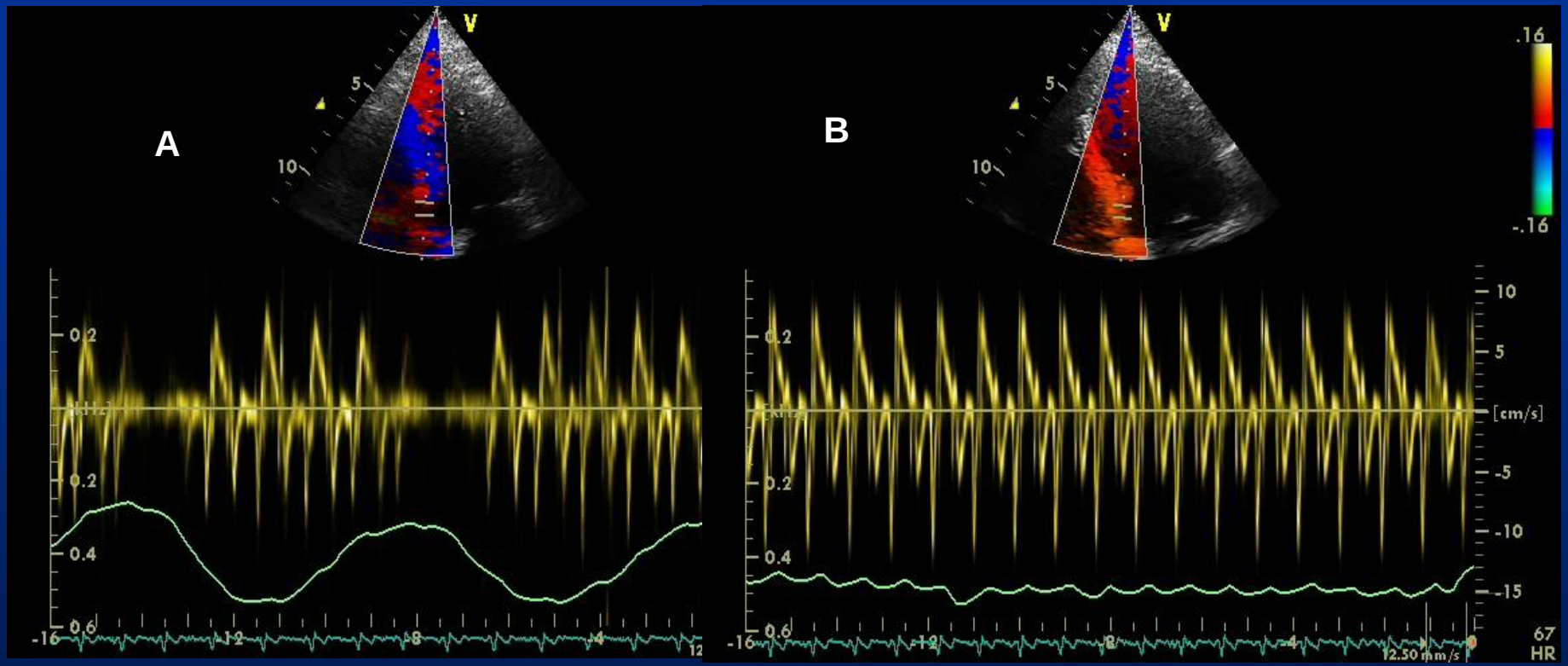


PHYSIOLOGICAL VARIATIONS OF THE VELOCITY ACROSS SUPRAHEPATIC VEINS, AND PULMONARY V DURING QUIET RESPIRATION IN A NORMAL HEART

→ MARKED RESPIRATORY CHANGES: INCREASE IN S, D AND RETROGRAD A FLOW

→ MINIMAL RESPIRATORY VARIATION

DOPPLER – MEASUREMENTS



SEPTAL ANNULAR VELOCITIES MEASURED BY TDI DURING QUIET RESPIRATION AND DURING END-EXPIRATORY APNEA

THE SHIFT IN HEART POSITION DURING RESPIRATION IN RELATION TO A FIXED DOPPLER SAMPLE VOLUME LEADS TO INACCURATE RECORDING / AND ERRORS IN VELOCITIES MEASUREMENT

WHICH DISAPPEAR DURING END-EXPIRATORY APNEA

WE CAN NOW ANSWER IN DETAIL

WHEN, WHY AND HOW TO USE NORMAL RESPIRATION DURING AN ECHO STUDY

WHEN	WHY	HOW
Poor 2D image quality	To optimize the quality of the echo view	**Expiration:** better parasternaland often apical access to the heart **Inspiration:** brings the diaphragm down improving access to the heart
M-mode measurements of the LV or 2D-quantitation	To avoid measurement errors due to excessive translational motion of the heart	**Quiet respiration/held end-expiration**
Doppler measurements (flow/tissue velocities)	To avoid measurement errors due to excessive translational motion of the heart	**End-expiratory apnea**

FOR GOOD VISUALISATION AND MEASUREMENTS OF ECHO IMAGING

THE IMPACT OF RESPIRATORY CYCLE

GENERAL ECHOCARDIOGRAPHIC DATA

ECHO EVALUATION OF HAEMODYNAMIC PARAMETERS

- RA PRESSURE
- SYSTOLIC PAP
- LV DIASTOLIC FUNCTION

ECHO DIAGNOSIS OF C-V DISEASES

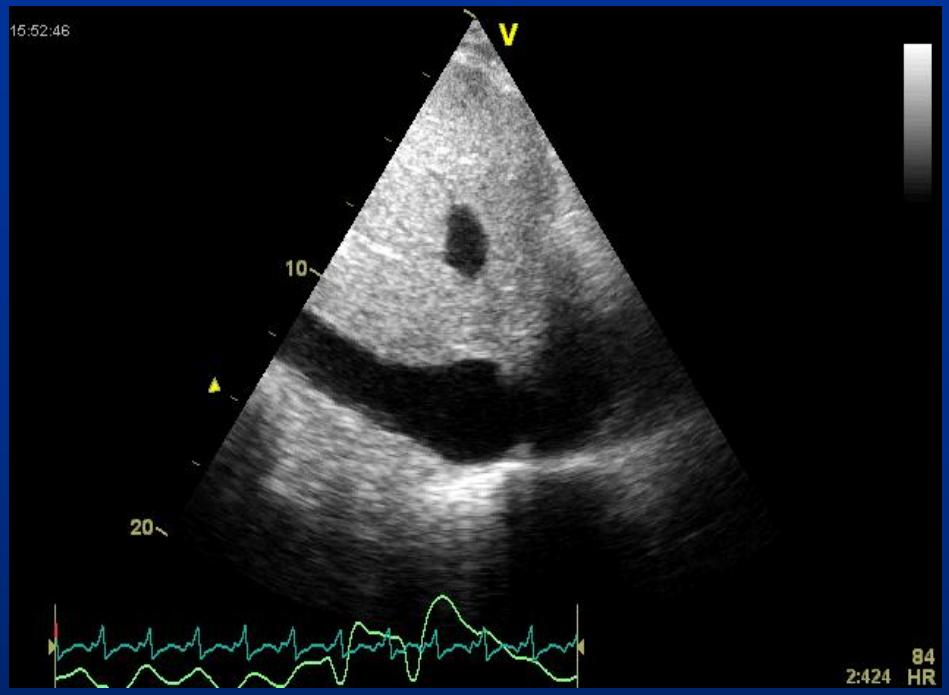
ESTIMATION OF RA PRESSURE

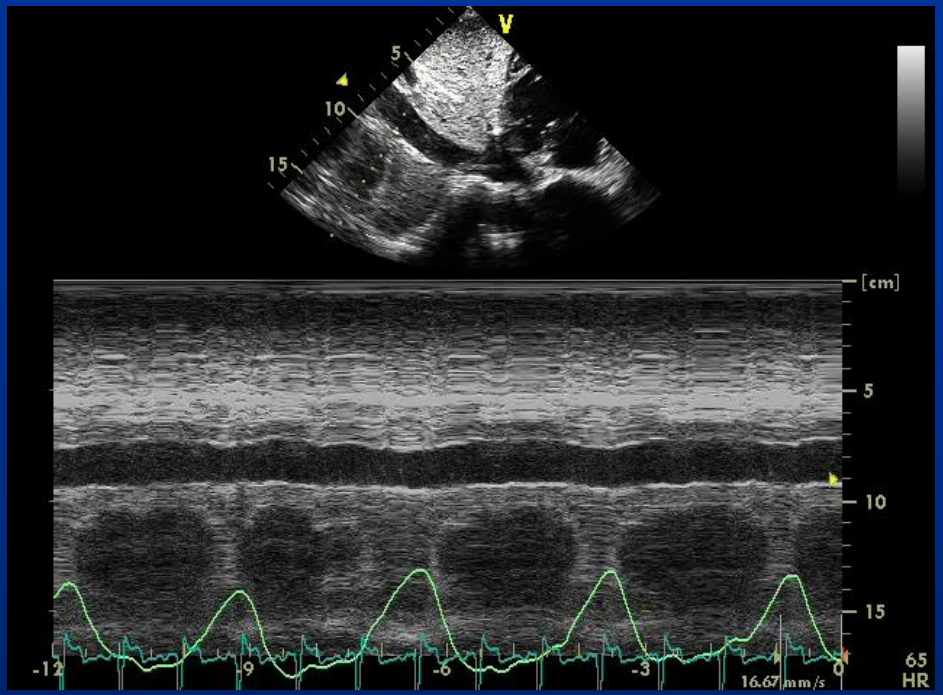
THE DIAMETER OF IVC DECREASES IN INSPIRATION AND THE **COLLAPSIBILITY INDEX** CORRELATES WITH **RA PRESSURE**

COLLAPSIBILITY	**HIGH > 55%**	**NORMAL 35-50%**	**LOW <35%**
IVC DIAMETER	**SMALL < 1,7 cm**	**NORMAL 1,7-21 cm**	**LARGE >2,1 cm**
RA PRESSURE	**< 5 mmHg**	**5 mmHg**	**10-20 mmHg**

DEFINING COLLAPSIBILITY AS/AND IVC AS… WE CAN ESTIMATE **RA PRESSURE**

KIRCHER BJ, AM J CARDIOL 1990
BRENNAN JM, JASE 2007





2D, M MODE ECHO WITH ECG SINCRONIZATION FROM SUBCOSTAL VIEW

THERE IS NO RESPIRATORY VARIATION OF IVC DIAMETER
INDICATING INCREASED RA PRESSURE
IN A PT. WITH DILATED CARDIOMYOPATHY AND SEVERE PH

EVALUATION OF SYSTOLIC PAP

RESPIRATORY VARIATION IN **SVC SYSTOLIC FORWARD** FLOW
MAY BE A USEFUL DOPPLER INDEX FOR
THE ASSESSEMENT OF SEVERITY OP PH
IN PTS WITH **CHRONIC OBSTRUCTIVE PULMONARY DISEASE**
THAT CANNOT BE ASSESSED BY CONVENTIONAL TTE
(BECAUSE OF EMPHYSEMA OR MEDIASTINAL DEVIATION)

KUNICHIKA N, JASE 2002

ASSESSMENT OF LV DIASTOLIC FUNCTION

SMALL CHANGES (<15%) OCCUR IN MITRAL INFLOW DOPPLER PATTERN IN HEALTHY SUBJECTS WITH SPONTANEOUS RESPIRATION

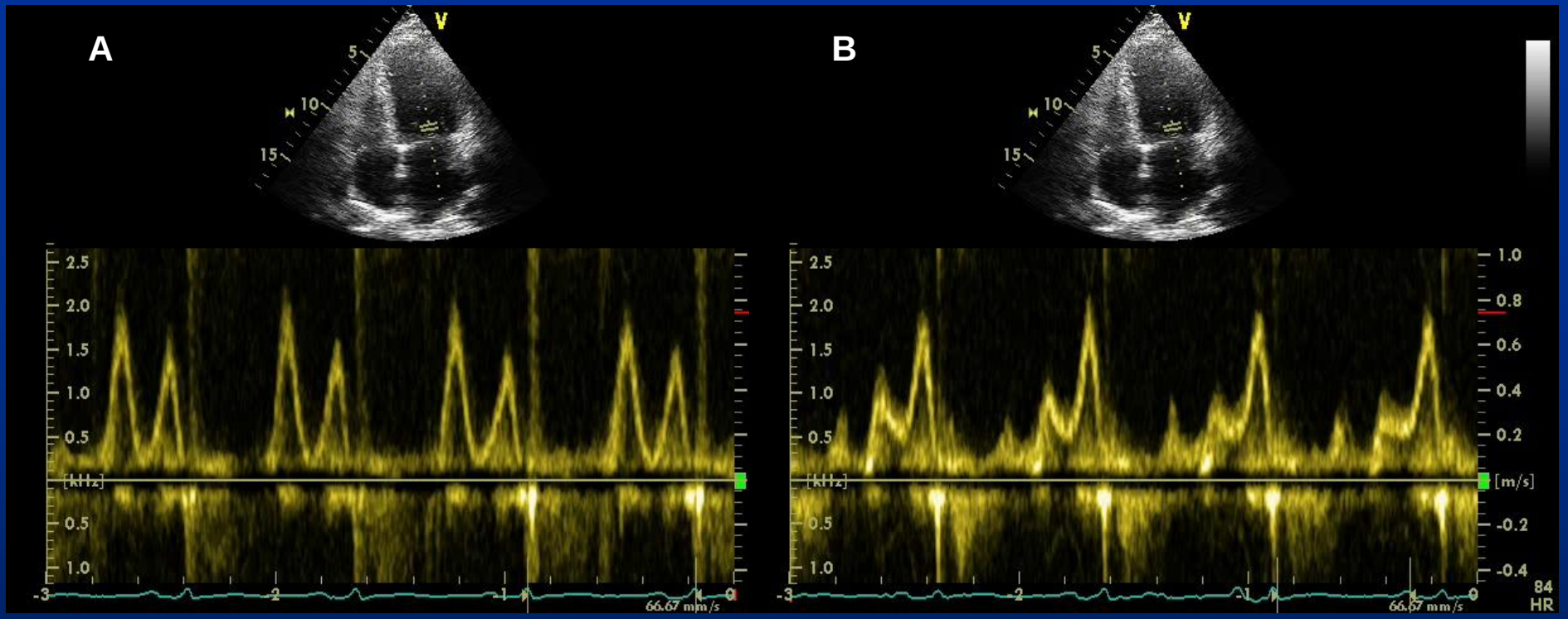
REDUCED E/A RATIO (<1) ON INSPIRATION
COULD CHARACTERIZE AN **ABNORMAL LV DIASTOLIC FUNCTION**
(OR JUST PSEUDO-N FILLING UNMASKED BY INSPIRATION)

TSAI LM, Am Heart J 1998
YUAN L, Echocardiography 2007

AN ABSOLUTE DECREASE IN THE MITRAL E/A RATIO AT STANDARDIZED **VALSALVA MANEUVER** CAN **PREDICT** AN ELEVATED LV FILLING PRESSURE WITH A SPECIFICITY OF 100%

THE **VALSALVA MANEUVER** CAN **UNMASK** THE PRESENCE OF ELLEVATED FILLING PRESSURE IN PTS. WITH A BASELINE PSEUDO-N RELLAXATION PATTERN

SCHWAMMENTHAL E, Am J Cardiolo 2000
NAGUEM SF, Eur J Echocard 2009



TTE, APICAL 4C VIEW, MITRAL INFLOW DOPPLER PATTERN

MITRAL INFLOW PATTERN APPEARS “NORMAL” AT REST
BUT DURING VALSALVA MANEUVER:

THE E/A RATIO DECREASES (1, 3 ↘ 6)
THE PEAK A VELOCITY INCREASES (60 ↗ 75 m/s)
UNMASKING THE IMPAIRED RELAXATION PATTERN

WE CAN NOW ANSWER IN DETAIL

WHEN, WHY AND HOW TO USE NORMAL RESPIRATION OR VALSALVA MANEUVER DURING UN ECHO STUDY

WHEN	WHY	HOW
Estimation of right atrial (RA) pressure	To elicit the inspiratory response of the inferior vena cava in order to assess the collapsibility index	**Inspiration/brief sniff**
Evaluation of systolic pulmonary artery pressure in patients with stable, chronic COPO that cannot been assessed by conventional TTE	To assess the respiratory variation in superior vena cava (SVC) systolic forward flow	**Normal respiration**
Assessment of left ventricular diastolic function	To unmask elevated LV filling pressure in patients with normal or reduced LV systolic function and pseudo-normal filling pattern at baseline impaired relaxation pattern at baseline	**Standardized Valsalva maneuver** decrease in the mitral E/A ratio of 0.5 or more during Valsalva increase in peak A wave velocity during Valsalva

IN CHARACTERIZING CARDIAC FUNCTION PARAMETERS

THE IMPACT OF RESPIRATORY CYCLE

GENERAL ECHOCARDIOGRAPHIC DATA

ECHO EVALUATION OF HAEMODYNAMIC PARAMETERS

ECHO DIAGNOSIS OF SOME C-V DISEASES

PERICARDIAL DISEASE
RESTRICTIVE CARDIOMYOPATHY
HYPERTROPHIC CARDIOMYOPATHY
MITRAL VALVE PROLAPS
ATRIAL SHUNT
TRICUSPID REGURGITATION

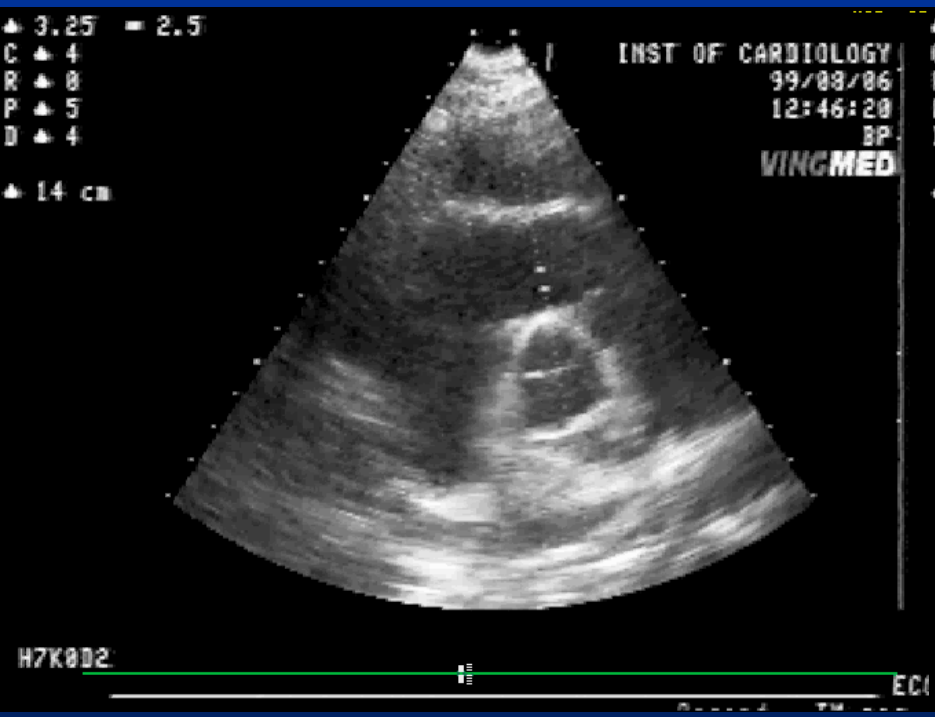
CARDIAC TAMPONADE

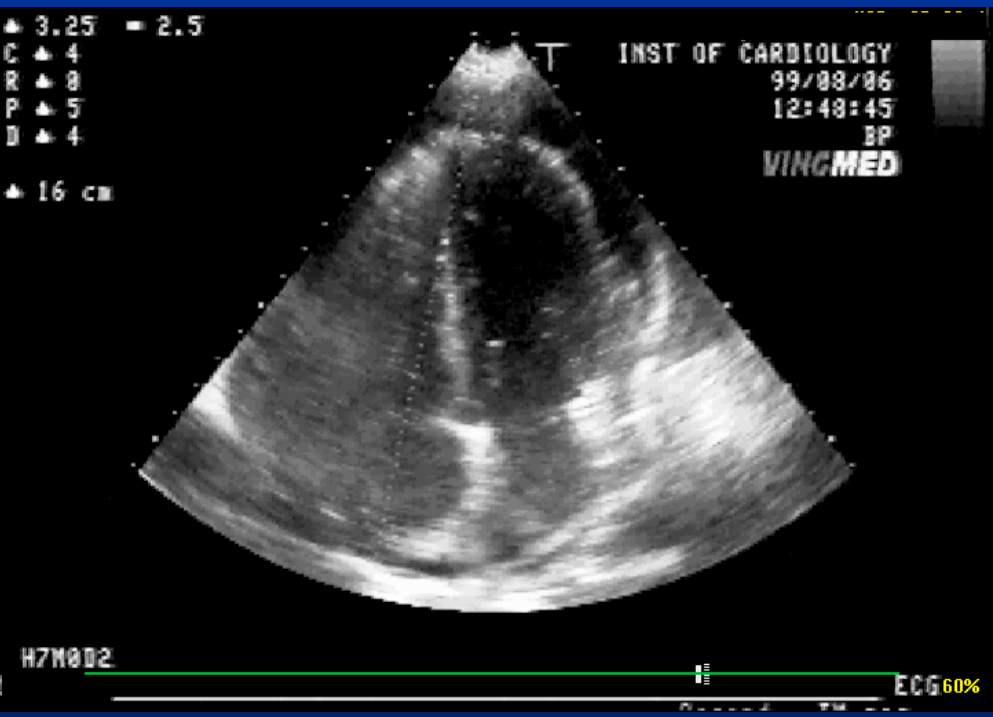
THE NORMAL EFFECTS OF RESPIRATION ARE **ACCENTUATED** BECAUSE THE INCREASED PERICARDIAL PRESSURE PRODUCES RECIPROCAL RESPIRATION CHANGES IN THE R AND LV VOLUME AND DYNAMICS

ECHO DEMONSTRATES **THE EXAGERATED PHASIC** VARIATION IN **CARDIAC VOLUME AND FLOW**:

- DURING EXPIRATION – THE DIASTOLIC COLLAPS OF THE RA/OR RV IS EXAGGERATED
- DURING INSPIRATION – THE EARLY RV DIASTOLIC FILLING IS AUGMENTED (>25%) WHILE LV DIASTOLIC FILLING DIMINISHES (> 15%)

SINGH S, CIRCULATION 1984
IVENS EL, HEART 2007





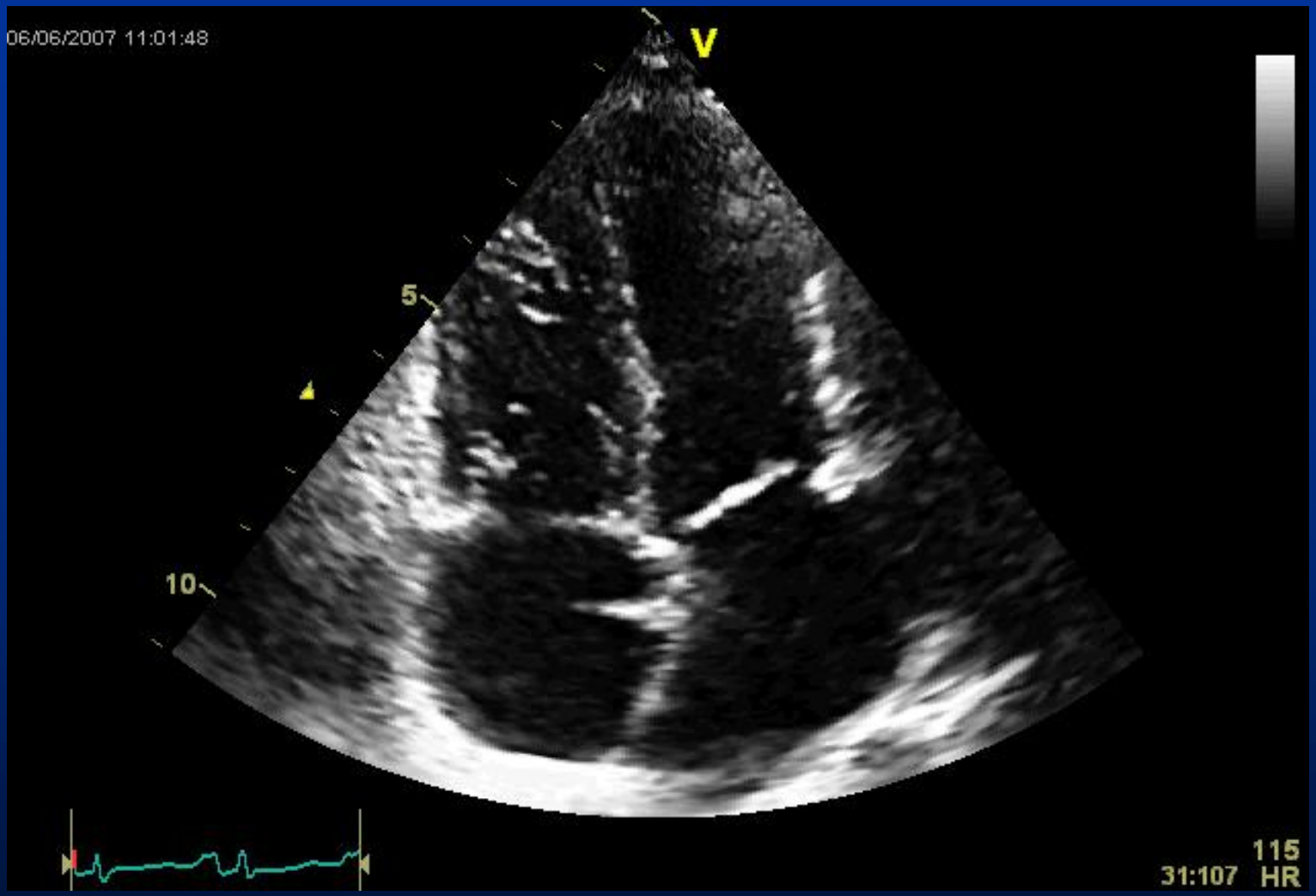
THE INTERMITENT DIASTOLIC COLLAPS OF THE FREE WALLS OF RA AND RV EXAGGERATED DURING EXPIRATION IN A CARDIAC TAMPONADE PT.

CONSTRICTIVE PERICARDITIS

THE RIGID PERICARDIUM **IMPEDES THE TRANSMISION OF INTRATHORACIC PRESSURE** TO CARDIAC CHAMBERS AND **INCREASES INTERVENTRICULAR INTERACTION**

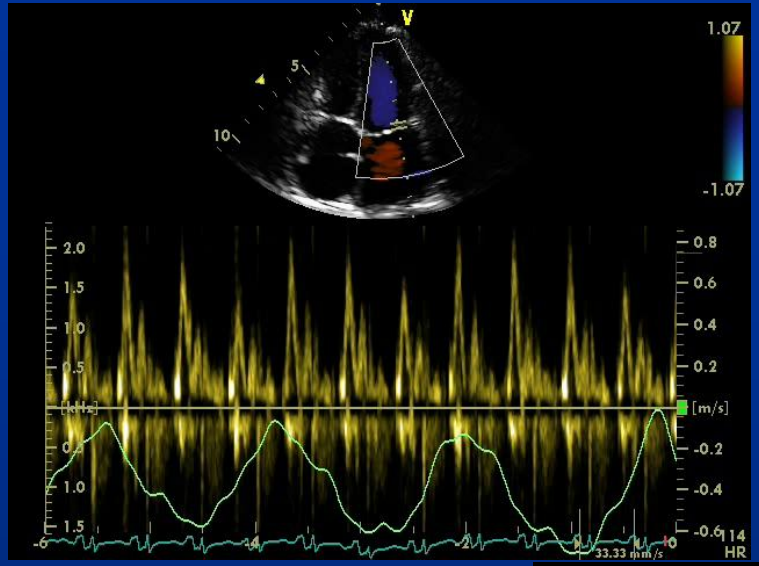
ABNORMAL HAEMODYNAMIC IS REFLECTED IN **DOPPLER DATA**: INTRACARDIAC; HEPATIC, PULMONARY VEIN; PROXIMAL AORTIC FLOW

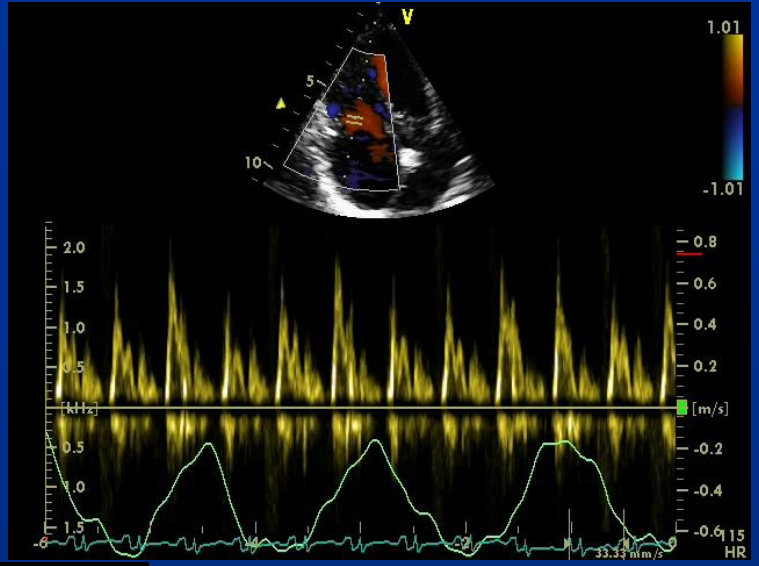
NISHIMURA RA, HEART 2001



INCREASED INTERVENTRICULAR INTERACTION IN CONSTRICTIVE PERICARDITIS

WITH RV VOLUME INCREASE THERE IS A CORRESPONDING DECREASE IN LV VOLUME DURING INSPIRATION





CONSTRICTIVE PERICARDITIS

RESPIRATORY VARIATION OF

A - TRANS-MITRAL DOPPLER FLOW: A DECREASE OF PEAK VELOCITY (>25%)
B - TRANS-TRICUSPIDIAN FLOW: AN INCREASE OF PEAK VELOCITY DURING INSPIRATION
C - HEPATIC VEIN FLOW: AN INCREASE OF A WAVE DURING EXPIRATION

RESTRICTIVE CARDIOMYOPATHY

COMPARISON IN RESPIRATORY CHANGES

	RCM	CP
Mitral inflow	No respiration variation of mitral inflow E wave velocity, IVRT E/A ratio >2, short DT, diastolic regurgitation	**Inspiration**: decreased inflow E wave velocity, prolonged IVRT **Expiration**: opposite changes, short DT, diastolic regurgitation
Pulmonary vein	Blunted S/D ratio (0.5), prominent and prolonged AR No respiration variation, D wave	S/D ratio = 1, **Inspiration**: decreased pulmonary vein S and D waves **Expiration**: opposite changes
Tricuspid inflow	Mild respiratory variation of tricuspid inflow E wave velocity, E/A ratio >2, TR peak velocity, no significant respiration change Short DT with inspiration, diastolic regurgitation	**Inspiration**: increased tricuspid inflow E wave velocity, increased TR peak velocity **Expiration**: opposite changes Short DT, diastolic regurgitation
Hepatic veins	Blunted S/D ratio, increased inspiratory reversals	**Inspiration**: minimally increased hepatic veins S and D **Expiration**: decreased diastolic flow/increased reversals

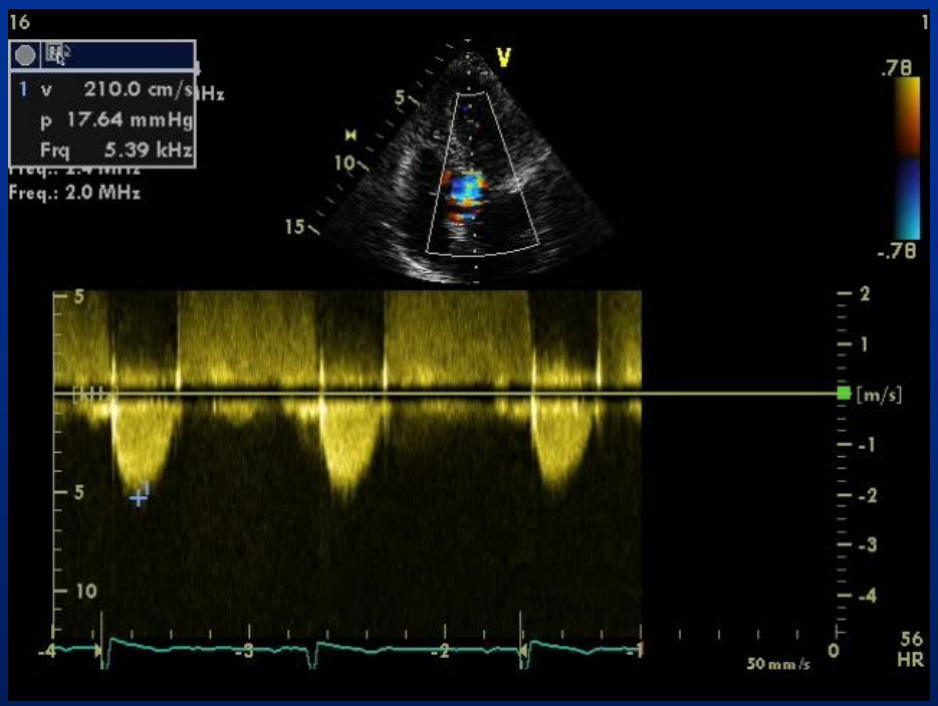
RESPIRATORY VARIATIONS ARE DECREASED IN RCM BECAUSE VENTRICULAR FILLING IS LIMITED BY THE NONCOMPLIANT RESTICTIVE MYOCARDIUM

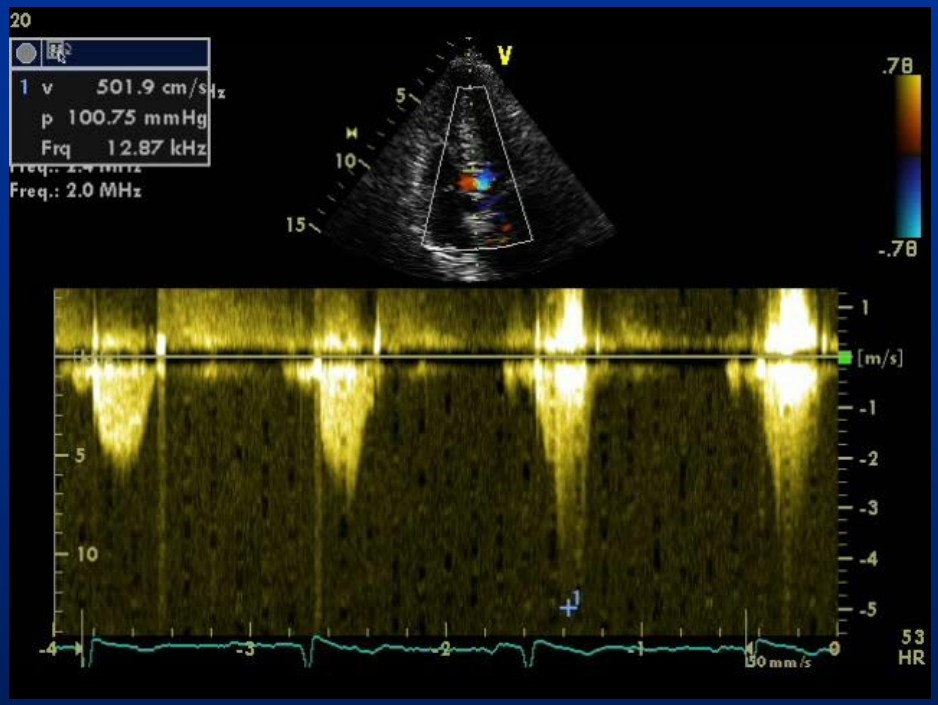
HYPERTROPHIC CARDIOMYOPATHY

THE VALSALVA MANEUVER **CAN UNMASK LATENT GRADIENTS** IN PTS. WITHOUT RESTING OBSTRUCTION

DURING THE STRAIN PHASE OF VALSALVA DUE TO DECREASE IN PRELOAD, END DIASTOLIC LV VOLUME AND AFTERLOAD

- SAM OCCURS **EARLIER** IN SYSTOLE
- MITRAL-SEPTAL CONTACT **LASTS LONGER**
- AND LV OUTFLOW TRACT GRADIENT **INCREASES**





TTE, 5 C VIEW, DOPPLER LV OUTFLOW PATTERN

68 YEAR-OLD FEMALE, HYPERTROPHIC CARDIOMYOPATHY

A – RESTING CW TRACE REVEALED A LOW LV OUTFLOW TRACT PEAK VELOCITY
B – DURING VALSALVA MANEUVER, PEAK VELOCITY AND GRADIENT INCREASES

MITRAL VALVE PROLAPS

DUE TO LV VOLUME DECREASE DURING VALSALVA MANEUVER
THE **REGURGITATION INCREASES**
AND **STARTS EARLIER** IN SYSTOLE

FEIGENBAUM H, ECOCHARDIOGRAPHY 2005

ATRIAL SHUNT

THE VALSALVA MANEUVER
MAY ENHANCE ATRIAL LEVEL SHUNTING
DURING RELEASE PHASE (III)
IN PATENT FORAMEN OVALE
MAKING THE SHUNT DETECTABLE
(USING CONTRAST TEE FOR A BETTER SENSITIVITY)

KERUT EK, ECOCHARDIOGRAPHY 2006

TRICUSPID REGURGITATION

THE MÜLLER MANEUVER
(PERFORMED BY FORCIBLY INSPIRING WHILE THE NOSE IS HELD CLOSED AND THE MOUTH IS SEALED FOR ABOUT 10 SECONDS)
AUGMENTS THE TRICUSPID REGURGITATION
(BECAUSE OF INCREASEDING RV FILLING)

REAGAN B.W,, ECOCHARDIOGRAPHY 2008

WE CAN NOW ANSWER IN DETAIL

WHEN, WHY AND HOW TO USE NORMAL RESPIRATION OR PROVOCATIVE MANEUVERS DURING AN ECHO STUDY

WHEN	WHY	HOW
Cardiac tamponade	To assess respiratory variation in cardiac volumes and flow	**Normal respiration**
Constrictive pericarditis	To assess the respiratory variation in mitral, tricuspid, pulmonary and hepatic vein flow	**Normal respiration**
Restrictive cardiomyopathy	To assess the respiratory variation in mitral, tricuspid, pulmonary and hepatic vein flow	**Normal respiration**
Detection of Patent Foramen Ovale by TTE or TEE	To assess the appearence of contrast in the LA shortly after injection of saline contrast into an upper extremity vein, with good opacification of the RA	**Normal respiration** within 3 cardiac cycles after injection of saline contrast **Valsalva maneuver** during the release phase
Hypertrophic cardiomyopat with mild or absent resting obstruction	To unmask latent gradient/to increase LVOT gradient	**Valsalva maneuver** during the release phase

IN VARIOUS CARDIAC DISORDERS

CONCLUSION

USING NORMAL RESPIRATORY PHASES AND PROVOCATIVE RESPIRATORY MANEUVERS CAN BE VERY USEFUL IN CARACTERIZING **NORMAL CARDIAC PARAMETERS** AND **VARIOUS CARDIAC DISORDERS**

THE EXTRA TIME REQUIRED TO PERFORM THESE MANEUVERS IS WORTHWHILE AND WELL COMPENSATED BY THE SIGNIFICANT INCREASE IN **EXAMINATION QUALITY** AND **DIAGNOSIS ACCURACY**