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 IntraPericardial 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 IntraPericardial 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

### 2D Echo

- Image Quality
- Measurements

## 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 INTERFERENCES DOES NOT ALLOW THE VISUALISATION OF CARDIAC STRUCTURE
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
2D – 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
Tissue Doppler Imaging: Principles and Applications

**2D - IMAGE QUALITY**

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

**TTA SHORT AXIS VIEW**

DURING NORMAL RESPIRATION
THE HEART MOVES MEDIALY
THE EXCESSIVE TRANSLATIONAL MOTION INTERFERES WITH THE VISUALISATION OF CARDIAC STRUCTURES
SUBCOSTAL VIEW

INSPIRATION BRINGS THE DIAPHRAGM DOWN
IMPROVING THE IMAGING OF THE HEART
AN INSPIRATORY REDUCTION IN LV END DIASTOLIC DIMENSION ASSESSED BY M-MODE ECHO WAS FOUND IN NORMAL SUBJECTS

THE INSPIRATORY 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
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
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
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
<table>
<thead>
<tr>
<th>WHEN</th>
<th>WHY</th>
<th>HOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor 2D image quality</td>
<td>To optimize the quality of the echo view</td>
<td>Expiration: better parasternal and often apical access to the heart</td>
</tr>
<tr>
<td>M-mode measurements of the LV or 2D-quantitation</td>
<td>To avoid measurement errors due to excessive translational motion of the heart</td>
<td>Quiet respiration/held end-expiration</td>
</tr>
<tr>
<td>Doppler measurements (flow/tissue velocities)</td>
<td>To avoid measurement errors due to excessive translational motion of the heart</td>
<td>End-expiratory apnea</td>
</tr>
</tbody>
</table>

FOR GOOD VISUALISATION AND MEASUREMENTS OF ECHO IMAGING

WE CAN NOW ANSWER IN DETAIL
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.

<table>
<thead>
<tr>
<th>Collapsibility</th>
<th>High</th>
<th>&gt; 55%</th>
<th>Normal</th>
<th>35-50%</th>
<th>Low</th>
<th>&lt;35%</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVC Diameter</td>
<td>Small</td>
<td>&lt; 1.7 cm</td>
<td>Normal</td>
<td>1.7-21 cm</td>
<td>Large</td>
<td>&gt;2.1 cm</td>
</tr>
<tr>
<td>RA Pressure</td>
<td>&lt; 5 mmHg</td>
<td></td>
<td>5 mmHg</td>
<td></td>
<td>10-20 mmHg</td>
<td></td>
</tr>
</tbody>
</table>

Defining collapsibility 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 ASSESSMENT OF SEVERITY OF PH IN PTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE THAT CANNOT BE ASSESSED BY CONVENTIONAL TTE (BECAUSE OF EMPHYSEMA OR MEDIASTINAL DEVIATION)
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)
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 RELAXATION PATTERN
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
## WHEN, WHY AND HOW TO USE NORMAL RESPIRATION OR VALSALVA MANEUVER DURING UN ECHO STUDY

<table>
<thead>
<tr>
<th>WHEN</th>
<th>WHY</th>
<th>HOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimation of right atrial (RA) pressure</td>
<td>To elicit the inspiratory response of the inferior vena cava in order to assess the collapsibility index</td>
<td>Inspiration/brief sniff</td>
</tr>
<tr>
<td>Evaluation of systolic pulmonary artery pressure in patients with stable, chronic COPO that cannot been assessed by conventional TTE</td>
<td>To assess the respiratory variation in superior vena cava (SVC) systolic forward flow</td>
<td>Normal respiration</td>
</tr>
<tr>
<td>Assessment of left ventricular diastolic function</td>
<td>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</td>
<td>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</td>
</tr>
</tbody>
</table>
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
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 EXAGGERATED PHASIC VARIATION IN CARDIAC VOLUME AND FLOW:

- DURING EXPIRATION – THE DIASTOLIC COLLAPS OF THE RA/OR RV IS EXAGGERATED (>25%)
- DURING INSPIRATION – THE EARLY RV DIASTOLIC FILLING IS AUGMENTED (>25%) WHILE LV DIASTOLIC FILLING DIMINISHES (> 15%)
THE INTERMITENT DIASTOLIC COLLAPS OF THE FREE WALLS OF RA AND RV EXAGGERATED DURING EXPIRATION IN A CARDIAC TAMONADE PT.
CONSTRUCTIVE 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
<table>
<thead>
<tr>
<th></th>
<th>RCM</th>
<th>CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitral inflow</td>
<td>No respiration variation of mitral inflow E wave velocity, IVRT</td>
<td><strong>Inspiration</strong>: decreased inflow E wave velocity, prolonged IVRT</td>
</tr>
<tr>
<td></td>
<td>E/A ratio &gt;2, short DT, diastolic regurgitation</td>
<td><strong>Expiration</strong>: opposite changes, short DT, diastolic regurgitation</td>
</tr>
<tr>
<td>Pulmonary vein</td>
<td>Blunted S/D ratio (0.5), prominent and prolonged AR</td>
<td>S/D ratio = 1, <strong>Inspiration</strong>: decreased pulmonary vein S and D waves</td>
</tr>
<tr>
<td></td>
<td>No respiration variation, D wave</td>
<td><strong>Expiration</strong>: opposite changes</td>
</tr>
<tr>
<td>Tricuspid inflow</td>
<td>Mild respiratory variation of tricuspid inflow E wave velocity,</td>
<td><strong>Inspiration</strong>: increased tricuspid inflow E wave velocity, increased TR peak velocity</td>
</tr>
<tr>
<td></td>
<td>E/A ratio &gt;2, TR peak velocity, no significant respiration change</td>
<td><strong>Expiration</strong>: opposite changes</td>
</tr>
<tr>
<td></td>
<td>Short DT with inspiration, diastolic regurgitation</td>
<td>Short DT, diastolic regurgitation</td>
</tr>
<tr>
<td>Hepatic veins</td>
<td>Blunted S/D ratio, increased inspiratory reversals</td>
<td><strong>Inspiration</strong>: minimally increased hepatic veins S and D</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Expiration</strong>: decreased diastolic flow/increased reversals</td>
</tr>
</tbody>
</table>

**RESTRICTIVE CARDIOMYOPATHY COMPARISON IN RESPIRATORY CHANGES**

**RESPIRATORY VARIATIONS ARE DECREASED IN RCM BECAUSE VENTRICULAR FILLING IS LIMITED BY THE NONCOMPLIANT RESTRICTIVE 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, ECHOARDIOGRAPHY 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)
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 INCREASED RV FILLING)

REAGAN B.W., ECHOCARDIOGRAPHY 2008
<table>
<thead>
<tr>
<th>WHEN</th>
<th>WHY</th>
<th>HOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac tamponade</td>
<td>To assess respiratory variation in cardiac volumes and flow</td>
<td>Normal respiration</td>
</tr>
<tr>
<td>Constrictive pericarditis</td>
<td>To assess the respiratory variation in mitral, tricuspid, pulmonary and hepatic vein flow</td>
<td>Normal respiration</td>
</tr>
<tr>
<td>Restrictive cardiomyopathy</td>
<td>To assess the respiratory variation in mitral, tricuspid, pulmonary and hepatic vein flow</td>
<td>Normal respiration</td>
</tr>
</tbody>
</table>
| Detection of Patent Foramen Ovale by TTE or TEE | To assess the appearance 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 cardiomyopathy with mild or absent resting obstruction | To unmask latent gradient/to increase LVOT gradient | Valsalva maneuver during the release phase |
CONCLUSION

USING NORMAL RESPIRATORY PHASES AND PROVOCATIVE RESPIRATORY MANEUVERS CAN BE VERY USEFUL IN CHARACTERIZING 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