

VANDERBILT UNIVERSITY
ADULT CARDIOTHORACIC ANESTHESIOLOGY FELLOWSHIP
TRANSESOPHAGEAL ECHOCARDIOGRAPHY CURRICULUM

Suggested Textbooks:

Clinical Manual & Review of Transesophageal Echocardiography
by Mathew & Swaminathan
Practical Perioperative Transesophageal Echocardiography by Sidebotham
A Practical Approach to Transesophageal Echocardiography by Perrino

WEEK ONE

TRANSESOPHAGEAL TOMOGRAPHIC VIEWS

Suggested Reading:

Mathew & Swaminathan, Chapter 5 (pages 87-121)
Sidebotham, Chapter 3
Perrino Chapter 2

Suggested PTE Masters.com Videos: *Intro Part 1,2, and 3*

Objectives:

1. Know the names of the 28 suggested views and how to obtain the suggested 28 views for a comprehensive TEE examination
(refer to *ASE Guidelines for Performing a Comprehensive TEE: Recommendations from the ASE & the SCA*, J Am Soc Echocardiography, 2013; 26: pages 921-964)
2. Identify all structures in each image

UNDERSTANDING ULTRASOUND SYSTEM CONTROLS

Suggested Reading:

Mathew & Swaminathan, Chapter 2 (pages 16-33)
Sidebotham, Chapter 1 & 2
Perrino, Chapter 1

Suggested PTE Masters.com Videos: *Knobology & Image Optimization*

Objectives: Understand the purpose and use of the following

1. Gain
2. Time, Depth and Lateral Gain Compensation
3. Compression
4. Power
5. Frequency

6. Harmonics
7. Focal Zone
8. Depth
9. Zoom
10. Freeze
11. Sector Size
12. Color Doppler
13. Pulse Wave vs. Continuous Wave Doppler

LEFT VENTRICULAR SYSTOLIC FUNCTION

Suggested Reading:

Mathew & Swaminathan, Chapter 6 (pages 125-138)

Sidebotham, Chapter 7

Perrino Chapter 3 & 4

Suggested PTE Masters.com Videos: *Systolic Function (Basic, Additional Topics, Advanced)*

Objectives:

1. Significance of the Pressure-Volume relationship/loop
2. Concept of "Load Dependence"
3. Normal LV dimensions and wall thickness
4. Evaluation of Cardiac output
5. (Load Dependent) Ejection Phase Indices
 - a. Fractional Shortening
 - b. Velocity of Circumferential Fiber Shortening
 - c. Fractional Area Change
 - d. Ejection Fraction
 - e. EF via Modified Simpson's Rule
6. (Load Dependent) Isovolumetric Indices
 - a. dP/dT
 - b. Wall stress
7. (Load Independent) Indices
 - a. End-systolic elastance
 - b. Preload recruitable stroke work
 - c. Preload-adjusted maximal power
 - d. Doppler Tissue Imaging, Strain, Color Kinesis, Use of contrast
8. Regional wall motion assessment/Seventeen-segment model

MITRAL VALVE

Suggested Reading:

Mathew & Swaminathan, Chapter 7 & 8 (pages 143-168 & 175-190)

Sidebotham, Chapter 9

Perrino Chapters 8, 9, & 10

Suggested PTE Masters.com Videos: *Mitral Valve Part 1-4 and MV Additional Topics*

Objectives:

1. Know all views to assess the MV
2. Anatomy of the MV and annular morphology
3. MV prolapse
4. MV regurgitation
 - a. Carpentier Classification
 - b. Pathophysiology of MR
 - c. Grading/severity of MR
 - i. 2-D Evaluation
 - ii. Color flow Doppler (color flow jet area)
 - iii. Vena Contracta Width
 - iv. Regurgitant Volume, Regurgitant Fraction & Effective Regurgitant Orifice Area (EROA)
 - v. Proximal Isovelocity Surface Area (PISA)
 - vi. Pulmonary Vein Flow Patterns
5. MV Stenosis
 - a. Pathophysiology of MS
 - b. Grading/severity of MS
 - i. 2-D Evaluation
 - ii. Color Flow Doppler (Turbulent Flow)
 - iii. Mean pressure gradient
 - iv. Mitral valve area (MVA)
 - v. Pressure Half-Time (PHT) & MVA via PHT method
 - vi. MVA via Deceleration Time
 - vii. MVA via continuity equation
 - viii. Mitral Valve Resistance
6. Mitral Valve Repair
 - a. Indications for Repair
 - b. Surgical Techniques
 - c. Mitral Annulus Calcification
 - d. SAM (Systolic Anterior Motion) and LVOT (LV outflow tract) obstruction after MV repair
 - e. Other complications after MV repair

AORTIC VALVE

Suggested Reading:

Mathew & Swaminathan, Chapter 9 (pages 195-215)

Sidebotham, Chapter 10

Perrino Chapter 11 & 12

Suggested PTE Masters.com Videos: *Aortic Valve* and *AV Additional Topics*

Objectives:

1. Know all views to assess the AV
2. Anatomy of the AV and annular morphology
3. Normal LVOT, annular, sinotubular junction and aortic root dimensions
4. Aortic Stenosis: AV, subvalvular and supra-annular
 - a. Pathophysiology of AS
 - b. Grading/severity of AS
 - i. 2-D Evaluation, including M-mode
 - ii. Color Flow Doppler (turbulent flow)
 - iii. Continuous-wave Doppler (CWD) envelope shape & density
 - iv. Pressure Gradients (mean gradient, peak gradient, peak velocity, peak instantaneous vs. peak-to-peak velocity)
 - v. Non/Sub-annular Stenosis
 - vi. Low Gradient Aortic Stenosis
 - vii. Aortic Valve Area (AVA)-continuity equation
 - viii. Indexed AVA
 - ix. Dimensionless Index/Velocity Ratio
5. Aortic Insufficiency
 - a. Pathophysiology of AI
 - b. Grading/severity of AI
 - i. 2-D Evaluation
 - ii. Color Flow Doppler
 - iii. Vena Contracta Width
 - iv. Jet width/LVOT width ratio
 - v. Pressure Half-Time and Deceleration Slope
 - vi. Descending aorta diastolic flow reversal
 - vii. Regurgitant Volume, Regurgitant Fraction and Effective Regurgitant Orifice Area (EROA)
 - viii. AV repair techniques vs. Replacement
 - ix. Cardioplegia Considerations with AI

WEEK TWO

TRICUSPID VALVE

Suggested Reading:

Mathew & Swaminathan, Chapter 10 (pages 222-231)

Sidebotham, Chapter 13

Perrino Chapter 14

Suggested PTE Masters.com Videos: *The Right Heart Part 1- 4*

Objectives:

1. Know all views to assess the TV
2. Anatomy of the TV and annular morphology
3. TV regurgitation
 - a. Pathophysiology of TR
 - b. Grading/ severity of TR
 - i. 2-D Evaluation
 - ii. Tricuspid Annulus Diameter
 - iii. Color Flow Doppler
 - iv. Vena Contracta Width
 - v. Hepatic Vein Flow
 - vi. Coronary Sinus Flow
 - vii. TV Regurgitant Jet Velocity, Right Ventricular Systolic Pressure (RVSP), Systolic Pulmonary Artery Pressure
4. TV stenosis
 - a. Pathophysiology of TS
 - b. Grading/severity of TS
 - i. 2-D Evaluation
 - ii. Color Flow Doppler
 - iii. RV inflow velocity
 - iv. Mean Gradient
 - v. Pressure Half-Time
 - vi. TV area via continuity equation

PULMONIC VALVE

Suggested Reading:

Mathew & Swaminathan, Chapter 10 (pages 232-236)

Sidebotham, Chapter 13

Perrino Chapter 14

Suggested PTE Masters.com Videos: *The Right Heart Part 1-4*

Objectives:

1. Know all views to assess the PV

2. Anatomy of the PV and annular morphology
3. Pulmonic Insufficiency
 1. Common causes of PI
 2. Grading/severity of PI
 - a. 2-D Evaluation
 - b. Color Flow Doppler
 - c. Regurgitant Length
 - d. Jet width/LVOT diameter ratio
 - e. CW Doppler signal (Density and Severity of Deceleration/Pressure Half-Time)
 3. Pulmonic Stenosis
 - a. Pathophysiology of PS
 - b. Grading/severity of PS
 - i. 2-D Evaluation
 - ii. Color Flow Doppler
 - iii. Mean and peak gradients
 - iv. Pulmonic Valve Area via continuity equation
 - v. CW Doppler envelope
 4. Pulmonary artery dimensions

RIGHT HEART FUNCTION

Suggested Reading:

Mathew & Swaminathan, Chapter 13 (pages 298-312)

Sidebotham, Chapter 13

Perrino Chapter 14

Suggested PTE Masters.com Videos: *The Right Heart Part 1-4*

Objectives:

1. Know all views to assess RV Function
2. Normal RV structure, function, and dimensions
3. Assessment of regional systolic function
4. Assessment of Global RV systolic Function
 - a. Tricuspid Annular Plane Excursion (TAPSE)
 - b. Ejection Fraction
 - c. Fractional Area Change
 - d. Dp/dT
 - e. Myocardial Performance Index
 - f. Cardiac Output (via RVOT area & RVOT VTI)
5. Assessment of RV Diastolic Function
 - a. Tricuspid Inflow Velocities
 - b. Hepatic Vein Flow
 - c. Tricuspid Annulus Tissue Doppler

PROSTHETIC VALVES

Suggested Reading:

Mathew & Swaminathan, Chapter 11 (pages 240-260)

Sidebotham, Chapter 12

Perrino Chapter 13

Suggested *PTE Masters.com* Videos: *Prosthetic Valves, Prosthetic Valves-Cases Part 1 & 2*

Objectives:

1. Know the different types and structure of prosthetic valves (mechanical, bioprosthetic and transcatheter aortic valves)
2. Know how to evaluate prosthetic valves
 - a. Normal findings of 2-D Imaging, Color Flow and Spectral Doppler (mean gradients) and EROA
3. Know prosthetic valve pathology
 - a. Patient-prosthesis mismatch
 - b. Endocarditis
 - c. Thrombosis/Thromboembolism
 - d. Fibrin Strands
 - e. Prosthesis Failure
 - f. Paravalvular Regurgitation
 - g. LVOT obstruction

QUANTITATIVE ECHOCARDIOGRAPHY

Suggested Reading:

Mathew & Swaminathan, Chapter 4 (pages 63-79)

Sidebotham, Chapter 21

Perrino Chapter 6

Suggested *PTE Masters.com* Videos: *Hemodynamic Calculations Part 1 and 2*

Objectives:

1. Understand the concept of Doppler Shift
 - a. Understand the use of the different Doppler modalities
 - b. Doppler Shift
 - c. Pulsed-Wave Doppler
 - d. Continuous-Wave Doppler
 - e. High Pulse Repetition Frequency Doppler
 - f. Color Flow Doppler
 - g. Tissue Doppler
2. Understand the Use of Doppler for Hemodynamic Assessment

- a. Measurement and conservation of Flow (Continuity Equation)
 - b. Measurement of Intracardiac Shunts
 - c. Velocity Acceleration
 - d. Measurement of Pressure (Bernoulli Equation)
 - e. Measurement of Resistance
 - f. Measurement of Contractility
3. Know how to quantify (and normal values of) the 4 chambers of the heart (LA, LV, RA & RV)

WEEK THREE

DIASTOLOGY

Suggested Reading:

Mathew & Swaminathan, Chapter 12 (pages 266-289)

Sidebotham, Chapter 8

Perrino Chapter 7

Suggested *PTE Masters.com* Videos: *Diastolic Function (Basic) Part 1, 2*, and *Diastolic Function (Advanced)*

Objectives:

1. Understand the timing of the cardiac cycle and the four phases of diastole
2. Understand the importance and pathophysiology of diastolic dysfunction
3. Know how to evaluate Diastolic Dysfunction
 - a. Transmitral Inflow (normal vs. abnormal patterns and limitations)
 - b. Pulmonary Vein Flow (normal vs. abnormal patterns and limitations)
 - c. Mitral Annulus Tissue Doppler Imaging (normal vs. abnormal patterns and limitations)
 - d. Propagation Velocity

ANATOMIC VARIANTS

Suggested Reading:

Mathew & Swaminathan, Chapter 3 (pages 36-46)

Sidebotham, Chapter 6 (pages 87-95)

Perrino Chapter 22

Suggested *PTE Masters.com* Videos: *Anatomic Variants and Pitfalls Part 1-3*

Objectives: Be able to identify the following

1. Anatomic Variants of the Right Atrium
2. Anatomic Variants of the Left Atrium
3. Anatomic Variants of the Right Ventricle and Left Ventricle
4. Extracardiac Spaces

AORTIC SURGERY

Suggested Reading:

Mathew & Swaminathan, Chapter 16 (pages 370-380)

Sidebotham, Chapter 11

Perrino Chapter 17

Suggested *PTE Masters.com* Videos: *The Thoracic Aorta*

Objectives:

1. Know all views to assess the thoracic aorta
2. Grading of Atheromatous plaque and calcification
3. Normal vessel dimensions
4. Aortic Aneurysm classification and evaluation
5. Aortic Dissection classification and evaluation
6. Endovascular Stenting and endoleak classification and evaluation

CARDIOMYOPATHIES**Suggested Reading:**

Mathew & Swaminathan, Chapter 14 (pages 316-342)

Sidebotham, Chapter 7 (pages 118-121)

Perrino Chapter 3

Suggested PTE Masters.com Videos: *Cardiomyopathies*

Objectives:

Know the etiology, pathophysiology, clinical presentation and how to evaluate

1. Dilated Cardiomyopathy
2. Hypertrophic Cardiomyopathy (SAM/LVOTO)
3. Restrictive and Infiltrative Cardiomyopathy
4. Miscellaneous cardiomyopathies (Tako-tsubo, LV Non-Compaction & Arrhythmogenic RV cardiomyopathy)

CONGENITAL HEART DISEASE**Suggested Reading:**

Mathew & Swaminathan, Chapter 18 (pages 406-433)

Sidebotham, Chapter 14

Perrino Chapter 19

Suggested PTE Masters.com Videos: *Intro to Congenital Heart Disease, Congenital Heart Disease Additional Topics Part 1-7*

Objectives: Be able to identify and assess the following

1. Identification of Morphologic Left and Right Heart Structures
2. Visceral Situs
3. Anomalies of Venatrial Connections (Persistent Left SVC, Anomalous Pulmonary Venous Return)
4. Atrial Situs
5. All types of Atrial Septal Defects
6. All types of Ventricular Septal Defects

7. AV canal defects
8. Mitral Valve Anomalies
9. Ebstein's Anomaly of the Tricuspid Valve
10. Bicuspid Aortic Valve
11. Tetralogy of Fallot
12. Anomalies of the great arteries
13. Truncus Arteriosus
14. Transposition of the Great Arteries (TGA) and Congenitally corrected TGA
15. Double-Outlet RV
16. Know common congenital cardiac surgical procedures
 - a. Glenn Shunt
 - b. Fontan Procedure
 - c. Atrial Switch
 - d. Ross Procedure

WEEK 4

HEART FAILURE SURGERY

Suggested Reading:

Mathew & Swaminathan, Chapter 17 (pages 387-400)

Sidebotham, Chapter 15 & 16

Perrino Chapter 15

Suggested PTE Masters.com Videos: *VADS part 1 & 2*

Objectives:

1. Understand the role of TEE in Heart Transplantation
 - a. Pre-transplant monitoring
 - b. Post-transplant monitoring
 - i. Key structures to assess
 - ii. Characteristic changes post-transplant
 - iii. Indicators of rejection
2. Understand the role of TEE in Mechanical Circulatory Support
 - a. Intra-aortic Balloon Pump
 - b. Left Ventricular Assist Devices
 - i. Pre-procedure assessment
 - ii. Assessment during Separation from Cardiopulmonary Bypass
 - iii. Postoperative assessment and complications
 - c. Right Ventricular Assist Devices

CARDIAC MASSES

Suggested Reading:

Mathew & Swaminathan, Chapter 19 (pages 440-446)

Sidebotham, Chapter 6 (pages 95-99)

Perrino Chapter 20

Suggested PTE Masters.com Videos: *Tumors Rumors and Bad Humors, Part 1-4*

Objectives: Identification of the following

1. Benign Cardiac Tumors
2. Malignant Primary Cardiac Tumors
3. Pericardial Tumors
4. Primary Tumors of the Aorta
5. Secondary Tumors of the Heart
6. Cardiac Thrombi
7. Atrial Septal Aneurysms
8. Endocarditis vegetations

PERICARDIAL DISEASES

Suggested Reading:

Mathew & Swaminathan, Chapter 15 (pages 351-364)

Sidebotham, Chapter 7 (pages 118-122) & Chapter 19 (pages 318-320)

Perrino Chapter 7

Suggested PTE Masters.com Videos: *Pericardial Disease Part 1-7*

Objectives:

1. Understand pericardial anatomy and physiology
2. Pericarditis and restrictive pericarditis
 - a. Pathophysiology
 - b. Evaluation of constrictive pericarditis
 - i. 2-D evaluation
 - ii. M-mode
 - iii. PW Doppler (Mitral inflow and Pulmonary Vein Flow)
 - iv. Tissue Doppler (Mitral Valve Annulus tissue velocities)
3. Cardiac Tamponade
 - a. Etiology and clinical presentation
 - b. Evaluation of Tamponade
 - i. 2-D Evaluation, RA and RV collapse
 - ii. PW Doppler (Mitral inflow and Pulmonary Vein Flow)
 - iii. Tissue Doppler (Mitral Valve Annulus tissue velocities)

PHYSICS & ULTRASOUND ARTIFACTS

Suggested Reading:

Mathew & Swaminathan, Chapter 1 & 3 (pages 1-9 & 46-51)

Sidebotham, Chapter 1

Perrino Chapters 1, 5 & 22

Suggested PTE Masters.com Videos: *Physics of Ultrasound Part 1-11 and Doppler Ultrasound*

Objectives: Understand the following

1. Nature and Properties of Ultrasound Waves
2. Properties of Pulsed Ultrasound
3. Propagation of Ultrasound through Tissues
4. Properties of the Ultrasound Transducer
5. The Six Components of an Ultrasound System
6. Ultrasound Imaging Modes
7. Determinants of 2-D Resolution
8. Principles of Doppler Ultrasound

- a. Pulse-Wave Doppler
 - b. Continuous-Wave Doppler
 - c. Color-Flow Doppler
9. Ultrasound Bioeffects
10. Identification of Ultrasound artifacts
- a. Reverberations
 - b. Acoustic Shadowing
 - c. Side-lobes
 - d. Refraction Artifact
 - e. Enhancement
 - f. Mirror Images
 - g. Electrical Noise and Acoustic Noise
 - h. Aliasing

EPICARDIAL AND EPIARTIC ULTRASONOGRAPHY

Suggested Reading:

Mathew & Swaminathan, Chapter 20 (pages 454-461)

Sidebotham, Chapter 5

Suggested *PTE Masters.com* Videos: *Epicardial & Epiartiaortic Echocardiography*

Objectives:

1. Know the names of all epicardial views
2. Identify all structures in each view