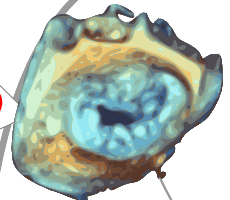
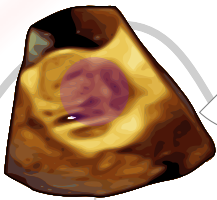


Toronto General Hospital

Perioperative Transesophageal Echocardiography Protocols

Version 1 - 2015.10.21



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All proceeds from the sale of this work will go towards funding research and educational work of the Lynn & Arnold Irwin Advanced Perioperative Imaging Lab.



Legend & Abbreviations

2D Zm	2D Zoom
CFD; C	Colour flow doppler ("C" with measurement symbols denotes CFD measurement)
CWD	Continuous wave doppler
CPB	Cardiopulmonary bypass
LAA	Left atrial appendage
MPR	Multi-planar reconstruction
PWD	Pulsed wave doppler
FW Strain	Free wall strain
GL Strain	Global longitudinal strain
TAPSE	Tricuspid annular plane systolic excursion
TDI	Tissue Doppler Imaging
VC	Vena contracta
Vmax	Maximum velocity
ΔP	Pressure gradient
○	Pre-CPB only
●	Post-CPB only
●	Pre- and Post-CPB
=	Calculated Value
↔	Linear measurement (2D or 3D MPR)
∠	Angle measurement (2D or 3D MPR)
▨	Area measurement (2D or 3D MPR)
‡ PW	Pulsed wave doppler measurement
↓ CW	Continuous wave doppler measurement
∞	Strain

Basic Assessment

Pre  |  Post CPB



- **ME4C 2D**
- CFD TV
- CFD MV
-  ‡ TDI Lat MV e'
-  ‡ PWD MV

- LV EF (Simpson's / 3D)
- RV function (at least 1)
 - ▨ RV FAC
 - ↔ TAPSE
 - ∞ RV GL/FW Strain



- **ME2C 2D**
-  ‡ PWD LAA



-  **LUPV** ‡ PWD



- **MEBC 2D**
-  CFD IAS



- **MELax 2D**
- 2D Zm AV
- CFD AV
- 2D Zm MV
- CFD MV

Document

Rhythm
BSA
Height

ABP*
CVP*
PAP*

Surgical procedure
Valve/device implanted
Major complications

* Ideally during contractility and other load dependant assessment



- **Mervio 2D**
- CFD TV
- ↓ CWD TV
-  CFD PV

- RVSP (↓ CW)



- **AVSax 2D**
-  CFD AV




- **TGMSax 2D**
- **DAoSax 2D**



- **AoArchLax 2D**

3D TEE Assessment Guide

Only measurements not included in the 2D protocols are indicated under MPR below.
High volume rate (HVR) may be used instead of 3D gated acquisition.
Target frame rates are for the 3D image. CFD images will have much lower rates.

Structure	Suggested Starting Point	Assessment	Optimal 3D Acquisition Modes	Frame rate	Include	2° acquisitions	Analysis
LV	ME4C, MELAX, ME2C	Systolic function	Gated 4-6 Full	> 10 Hz > 20 Hz → a3DQ 		Cropped ME4C, ME2C	3D LVEF (QLAB 3DQ, a3DQ, TomTec)
RV	ME4C	Systolic function	Gated 4-6 Full	> 10 Hz (> 20 Hz ideal)	LV	Cropped ME4C	3D RVEF (Tomtec)
MV	MELAX, ME4C	Screening	Live Zoom	> 10 Hz		En Face, PM comm.	MPR
		MR	+CFD Gated 4-6 Zoom / Full	> 20 Hz	AV, LVOT	En face, AL comm., PM comm., Ventricular	MPR: 2D valve measures + VC area on CFD
		MS	Gated 4-6 Zoom / Full	> 10 Hz		En Face, Cropped ME4C	MPR: Valve area planimetry
AV	MELAX	Screening	Live Zoom	> 10 Hz			
		AI	+CFD Gated 4-6 Zoom / Full	> 20 Hz	LVOT to prox Asc. Ao		MPR: VC area on CFD
		AS	Gated 4-6 Zoom / Full	> 10 Hz			MPR: Valve area planimetry
TV	ME4C	Screening	Live Zoom	> 10 Hz	Part of AV for orientation		
		TR	+CFD Gated 4-6 Zoom / Full	> 10 Hz (> 20 Hz ideal)			MPR: VC area on CFD (difficult)
IAS	MEBC	ASD/PFO	+CFD Gated 4-6 Zoom / Full	> 10 Hz	Part of SVC and AV for orientation		MPR: ASD dimensions, ASD rim
		Trans-sept. punct. guidance	Live Zoom / X-plane (Multi-D)	> 10 Hz			
LAA	ME2C	Screening / thrombus	Live Zoom / X-plane (Multi-D)	> 10 Hz (> 20 Hz ideal)	Part of MV & LUPV for orientation		
		Closure Device	Gated 4-6 Zoom / Full	> 5 Hz			MPR: LAA dimensions
Desc. Aorta	DAoSax	Plaque, Dissection	+CFD X-plane (Multi-D) Live Zoom large plaques	> 5 Hz		LAX/SAX high risk lesions	MPR: measure large lesions

Aortic Valve

Pre | Post CPB AI / AS only



3D Ao Root (opt)

3D CFD (opt)



AVSax 2D

CFD AV



MELax 2D Zm AV

CFD AV & LVOT

M-mode CFD LVOT



AAoLax 2D

DTG CFD AV



∇ PWD LVOT

\downarrow CWD AV

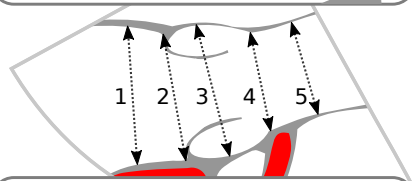


DAoLax CFD

∇ PWD DAo

- LVOT \uparrow 1
- Annulus \uparrow 2
- SOV \uparrow 3
- STJ \uparrow 4
- Proximal Asc. Aorta \uparrow 5
- AI 3D VC area (opt)
- AI VC
- Coaptation length \downarrow
- AI jet : LVOT

2D measures can also be made in 3D MPR



- LVOT VTI & V_{max} (∇ PW)
- VTI & V_{max} (\downarrow CW)
- $\Rightarrow \Delta P_{peak}, \Delta P_{mean}, AVA$
- PHT (\downarrow CW)

Pre-surgical assessment

1. Confirm **diagnosis** & **severity**

AS: 2D, 3D, gradients & AVA;

AI: 2D, 3D, VC, PHT, %LVOT, DAo diast. rev.

2. Identify **mechanism** & **viability of repair** (if planned)

3. **Sub-valvular** or **supra-valvular** / **aortic** pathology?

4. Associated **LV** pathology: **Dilation**? **Hypertrophy** / **LVOTO**?

5. Associated **MV** pathology?

Post-surgical assessment

1. **Coaptation length** (valve sparing repair; MELax)

2. Proximal end of coaptation above **annular plane**? (MELax)

3. Paravalvular or central **leak**? (MELax, MEAVSax)

4. New **SAM** or **LVOTO**? (MELax)

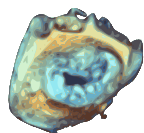
5. **Iatrogenic AS**? ΔP_{mean} & V_{max} (DTG)

6. New **SWMA** suggesting **coronary injury**? (TGMSax; AVSax RCA/LM)

7. Iatrogenic **aortic injury** or dissection? (AAo / DAo)

Mitral Valve

Pre ① | ② Post CPB MR / MS only



● **3D** (→ 3D guide)

● **3D CFD**

● **ME4C 2D Zm MV**

● CFD

● ↓CWD

● **MEBiCom 2D Zm MV**

● CFD

● **ME2C 2D Zm MV**

● CFD

● 2D LAA

● CFD + ‡PWD LAA

● **MELax 2D Zm MV**

● CFD MV

● CFD AV

● RUPV ‡PWD

● LUPV ‡PWD

● **MEBC 2D**

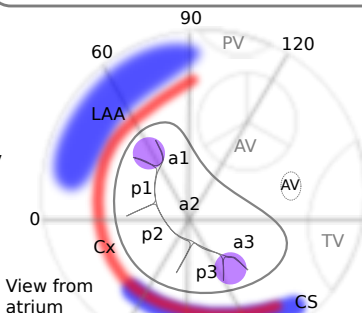
● CFD IVC

● CFD SVC

● **TGBSax 2D**

● **TGMSax 2D**

● ΔP_{peak} , ΔP_{mean}
● PHT (↓CW)



● MV annulus

● MR VC

● MR 3D VC area (opt)

● Tenting height ↓ (Func MR)

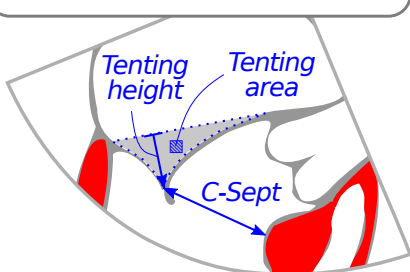
● Tenting area ▨ (Func MR)

● C-Sept ↓ (Org MR)

● AML/PML length (Org MR)

● MVA 3D planimetry (opt)

2D measures can also be made in 3D MPR



① Pre-surgical assessment

1. Confirm **diagnosis & severity**
2. Identify **mechanism & viability of repair** (if planned)
3. LV **morphology** and **function**? (EF; SWMA? Consider LV strain)
4. Associated **AV pathology**?
5. **LA dilation** or **LAA thrombus**?

① Post-surgical assessment

1. **Mean gradient**
2. Residual **MR** or paravalvular **leak**?
3. **SAM** or **LVOTO**?
4. New **AI**?
5. Injury to **bicaaval cannulation sites**?
6. New **SWMA** suggesting **circumflex** injury?


Tricuspid Valve

Pre  |  Post CPB



 **ME4C 2D Zm TV**


 CFD TV

 ↓ CWD TV



 **Mervio 2D TV**


 CFD TV

 ↓ CWD TV



 **MEBCmodTV 2D TV**

 CFD TV

 ↓ CWD TV



 **IVC Lax CFD Hep. V.**

 ‡ PWD Hep. Vein












 **TGBSax 2D TV**

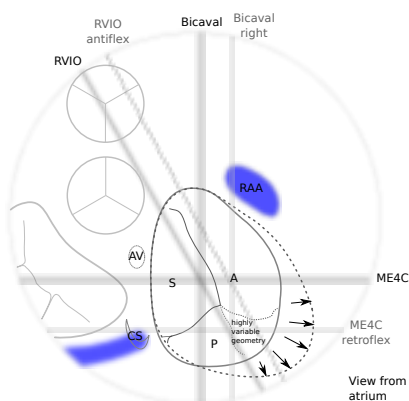
 CFD TV



 **TGRVI 2D TV**

 CFD TV

-  TV annulus (0°)
-  **TR vena contracta**
-  ΔP_{mean}
-  RV function (at least one)
 -  RV FAC
 -  ↔ TAPSE
 -  ∞∞∞ RV GL Strain
 -  ∞∞∞ RV FW Strain
-  RVSP (↓ CW)



Pre-surgical assessment

1. Confirm **diagnosis & severity**
2. Identify **mechanism & viability of repair** (if planned)
3. **RV morphology & function:** FAC / TAPSE / RV strain
4. **Pulmonary hypertension?**

Post-surgical assessment

1. **Mean gradient**
2. Residual **TR**, paravalvular or central **leak**?
3. New **SWMA** suggesting coronary (**RCA**) injury?
4. **RV function:** At least one of FAC / TAPSE / RV strain
5. Bicaval **cannulation site** injury?

Pulmonary Valve

Pre ● | ● Post CPB



ME4C 2D Zm RV

CFD TV

↓ CWD TV



MERVIO 2D PV

CFD PV

CFD TV

↓ CWD TV



AoArchSax 2D PV

CFD PV

↓ CWD PV



TGRVO 2D PV

CFD PV

↓ CWD PV

- TV annulus (0°)
- RV function (at least one)
 - ▨ RV FAC
 - ↔ TAPSE
 - ... RV GL Strain
 - ... RV FW Strain
- RVSP (↓ CW)



- PV annulus
- ΔP_{mean} (↓ CW)

● Pre-surgical assessment

1. Confirm **diagnosis** & **severity**
2. **RV morphology & function**: FAC / TAPSE / RV strain
3. **TV morphology & function**
4. Function of **previous repairs** (e.g. VSD patch)
5. **Pulmonary hypertension?**

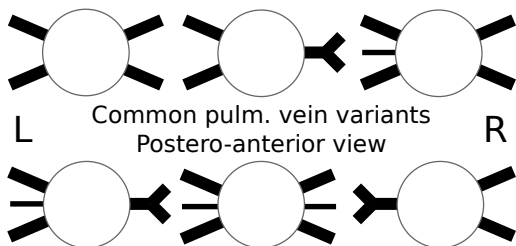
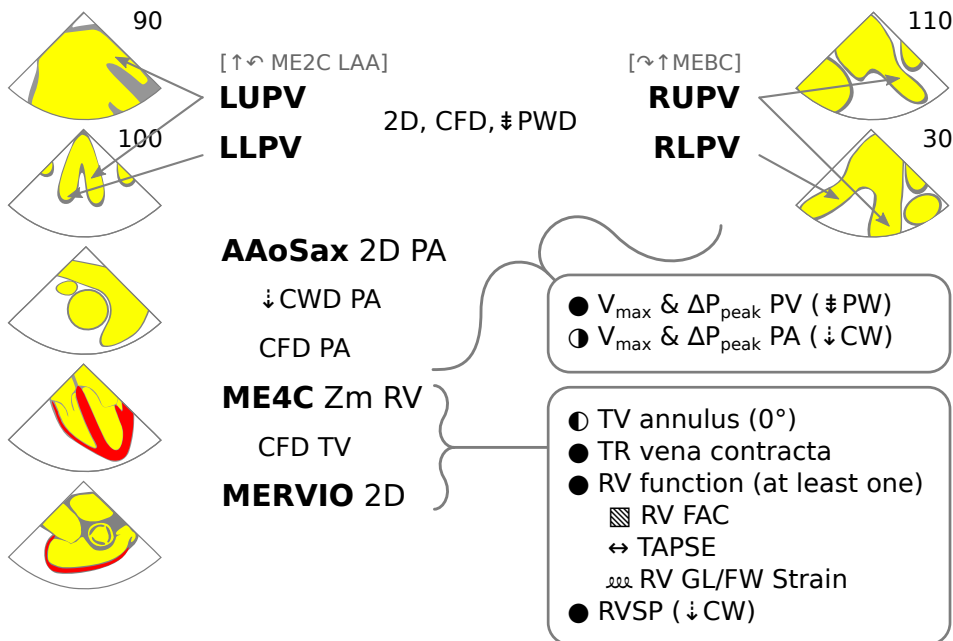
● Post-surgical assessment

1. **Mean gradient**
2. Paravalvular or central **leak?**
3. New **SWMA** suggesting **LAD** or **LM** coronary injury?
4. **RV function**: FAC / TAPSE / RV strain

Lung Transplant

Pre ● | ○ Post

All vein views are mid-esophageal
Large variation in angles and technique



○ Pre-surgical assessment

1. **RV morphology & function:** FAC / TAPSE / RV strain
2. **Tricuspid regurgitation?**
3. **Pulmonary hypertension?** RVSP (‡CW)
4. **Pulmonary regurgitation?** Pulmonary or RVOT **stenosis?**

○ Post-surgical assessment

1. Obstruction, thrombus or air in **venous anastomosis?**
Laminar flow; ‡PV ≥ 5mm; ‡PWD < 100 cm/s
2. Obstruction in **arterial anastomoses?**
3. **TV** and **PV** assessment
4. **Pulmonary hypertension?** RVSP
5. **RV function:** At least one of FAC / TAPSE / RV strain
6. (If on CPB) **cannulation site** injury?

Septal Myectomy

Pre ☐ | ☐ Post CPB



● 3D Ao Root & LVOT (opt)

● 3D CFD LVOT (opt)

● MELax 2D LVOT

● CFD AV & LVOT

● CFD MV

● CFD LV Cavity

● CFD IVS

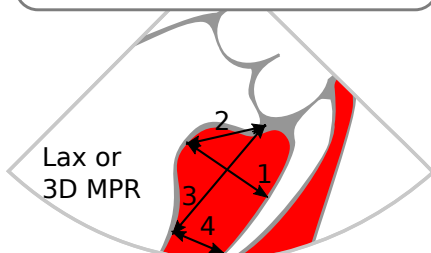
● ME4C 2D Zm MV

● CFD MV

● DTG CFD LV Cavity

● ↓CWD LVOT

- Max. septal thickness¹
- ① Distance from RCC base²
- ③ Length of thickening³
- ④ Distal septal thickness⁴



- LVOT V_{max} & ΔP_{max}

● Pre-surgical assessment

1. **LVOT obstruction** or turbulence? Measure gradient.
2. Define **obstructing area** (extent of required resection)
3. **SAM? MR?** Assess severity and mechanism.
4. **Mid-cavitary obstruction** or turbulence?

● Post-surgical assessment

1. Residual **LVOT obstruction** or turbulence? Measure gradient
2. Residual **SAM? MR?** Assess severity and mechanism.
3. Iatrogenic **VSD?**
4. Injury to **AV?**

LVAD Implantation

Pre ● | ○ Post CPB



● ME4C 2D

- CFD TV*
- 2D Zm LV Apex
- ↓CWD MV
- CFD LVAD inflow
- ↓CWD LVAD inflow
- ‡PWD LVAD inflow



● MERVIO 2D RV

- CFD TV
- CFD PV



● MEBC 2D IAS

- CFD IAS +/- bubble



○ ME2C 2D Zm LAA

- CFD LAA
- ‡PWD LAA



● AVLax 2D Zm AV

- CFD AV



○ AVLax / AscAoLax

- CFD LVAD outflow
- ↓CWD LVAD outflow
- ‡PWD LVAD outflow

- TV Annulus ↔
- TR Vena contracta ↔
- MV ΔP_{mean} ↓C
- RV function (at least one)
 - ▨ RV FAC
 - ↔ TAPSE
 - ⋈ RV GL Strain
 - ⋈ RV FW Strain
- V_{max} LVAD inflow (↓C + ‡P)

- V_{max} LVAD outflow (↓C + ‡P)

○ Pre-surgical assessment

1. **Thrombus?** (LV apex, LAA)
2. **MS?**
3. **RV function:** At least one of FAC / TAPSE / RV strain
4. **TV/PV disease?** Complete TV/PV study if sig. abnormal CFD
5. **Shunt** (PFO/ASD/VSD)? (Risk of R→L shunt with LVAD)
6. **AI?** (Risk of circular flow with LVAD)

○ Post-surgical assessment

1. Adequate **LV decompression?**
2. **RV function?**
3. LVAD **inflow/outflow obstruction**/turbulence? In/outflow V_{max}
4. **Shunt?** (PFO may show new flow after LVAD)
5. **AI?**

Selected References

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