Adult Congenital Echocardiographic Protocols

The department of Grown Up Congenital Heart Disease

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Introduction

Congenital heart disease (CHD), with its worldwide incidence of 0.8%, is one of the most common inborn defects. Advances in paediatric cardiology and cardiac surgery over the past several decades have led to more than 85% of these patients surviving to adulthood. This wonderful medical story has transformed the outcome for CHD and created what is a large and still-growing population of adolescent and adult patients. However, most early interventions for these patients – surgical or interventional - were palliative and not curative, presenting with new clinical challenges.

Echocardiography, with its wide range of modalities, is a great tool in the diagnosis and follow-up of adult patients with CHD. It provides comprehensive assessment of anatomy and physiology and contributes significantly to clinical management many years after surgical or percutaneous interventional procedures.

This book provides us with detailed echocardiographic protocols to systematically assess the most frequently encountered congenital abnormalities seen in adulthood. With these echocardiographic protocols, a thorough systematic examination of the pre or postoperative cardiac anatomy and hemodynamic situation from your patient can be acquired. Your echo lab data will become standardized which is not only beneficial for the follow up of the patient but also interchangeable with other echo labs for the benefit of research.

As with any medical textbook, the rapid advances in our field will soon require that new information be added to maintain its relevance. It is, therefore, important to us to hear from the users of this book how to improve the next edition.
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>Abd</td>
<td>Abdominal</td>
</tr>
<tr>
<td>AoS</td>
<td>Aortic valve stenosis</td>
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<tr>
<td>AR</td>
<td>Aortic regurgitation</td>
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<tr>
<td>Art.</td>
<td>Arteriosus</td>
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<tr>
<td>ASD</td>
<td>Atrial septal defect</td>
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<tr>
<td>AV</td>
<td>Atrio-ventricular</td>
</tr>
<tr>
<td>CAVSD</td>
<td>Complete atrioventricular septal defect</td>
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<tr>
<td>CW</td>
<td>Continuous wave</td>
</tr>
<tr>
<td>DCRV</td>
<td>Double chamber right ventricle</td>
</tr>
<tr>
<td>Desc</td>
<td>Descending</td>
</tr>
<tr>
<td>DET</td>
<td>Deceleration time</td>
</tr>
<tr>
<td>Dim</td>
<td>Dimension</td>
</tr>
<tr>
<td>3D</td>
<td>Three-dimensional echocardiography</td>
</tr>
<tr>
<td>DORV</td>
<td>Double outlet right ventricle</td>
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<tr>
<td>EF</td>
<td>Ejection fraction</td>
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<tr>
<td>4CH</td>
<td>Four chamber</td>
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<tr>
<td>HPLH</td>
<td>Hypoplastic left heart syndrome</td>
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<tr>
<td>IAS</td>
<td>Interatrial septum</td>
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<tr>
<td>IVC</td>
<td>Inferior vena cave</td>
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<tr>
<td>LA</td>
<td>Left atrium</td>
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<tr>
<td>LAX</td>
<td>Long axis</td>
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<tr>
<td>LLPV</td>
<td>Left lower pulmonary vein</td>
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<tr>
<td>LPA</td>
<td>Left pulmonary artery</td>
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<tr>
<td>LUPV</td>
<td>Left upper pulmonary vein</td>
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<tr>
<td>LV</td>
<td>Left ventricle</td>
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<tr>
<td>LVOT</td>
<td>Left ventricular outflow tract</td>
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<tr>
<td>MPG</td>
<td>Mean pressure gradient</td>
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<tr>
<td>MR</td>
<td>Mitral Regurgitation</td>
</tr>
<tr>
<td>MVA</td>
<td>Mitral valve area</td>
</tr>
<tr>
<td>PAVSD</td>
<td>Partial atrioventricular septal defect</td>
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<tr>
<td>PE</td>
<td>Pericardial effusion</td>
</tr>
</tbody>
</table>

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PFO  Patent foramen ovale
PHT  Pressure half time
PISA  Proximal isovelocity surface area
PR  Pulmonary valve regurgitation
PS  Pulmonary valve stenosis
Pulm  Pulmonary
PVA  Pulmonary venous atrium
PW  Pulsed wave
RA  Right atrium
RUPV  Right upper pulmonary vein
RV  Right ventricle
RVOT  Right ventricular outflow tract
SAX  Short axis
STJ  Sino-tubular junction
SVA  Systemic venous atrium
SVC  Superior vena cava
TAPSE  Tricuspid annular plane systolic excursion
TCPC  Total cavopulmonary connection
TDI  Tissue Doppler imaging
4 Fallot  Tetralogy of Fallot
ccTGA  Congenital corrected Transposition of the great Arteries
TGA  Transposition of the Great Arteries
TR  Tricuspid regurgitation
2CH  Two chamber
VA  Ventriculo-arterial
VSD  Ventricular septal defect
VTI  Velocity- time integral
User Guide:

- knowledge of basic imaging views is assumed
- before scanning a post operative congenital patient, review the cardiac anatomy and surgical reports!
- always note height – weight – BSA
- protocol 1 or 2 is the reference protocol for all patients visiting the lab for the first time
- follow up studies: use the lesion based protocols. Each of these protocols is designed to obtain specific information for that lesion.
- a combination of protocols may be necessary for one patient
- the referring cardiologist has a choice between an extensive or short protocol for the “follow up” echocardiogram
- text in italic or thickened is recommended

Observe the following settings

- **LV functional assessment**
  
  Apical and Parasternal Short Axis scans **Frame Rate > 60Hz** (ensures that the images can be analysed for Speckle Tracking)

  Visual assessment of LV function: EF<50% or abnormal shaped LV. 3D volume and ejection fraction where possible.

- **RV functional assessment**

  Visual assessment of RV function: EF<50%. 3D volume and ejection fraction where possible

- All right heart Doppler measurements: 1st beat at peak inspiration

- CW tricuspid regurgitation: measure either from the apical 4chamber view, parasternal short axis view or a parasternal long axis RV inflow view.

- **Doppler**

  - decrease colour Doppler scale (low Nyquist limits) for pulmonary vein visualization and for evaluation of patients with a Fontan circulation
PROTOCOL 9: measure the aortic velocity with PW to avoid misinterpretation of the pulmonary flow for aortic flow
## Guideline for echocardiographic follow-up in adults with congenital heart disease.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Follow-up</th>
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<tbody>
<tr>
<td>ASD II</td>
<td></td>
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<tr>
<td>- uncorrected</td>
<td>Every 3 – 5 years</td>
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<tr>
<td>- corrected</td>
<td>1 and 5 year after correction.</td>
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<tr>
<td></td>
<td>After 5 years final follow-up, providing no residual lesions.</td>
</tr>
<tr>
<td>ASD after percutaneous closure</td>
<td>After 3 weeks, 1 year and 5 years.</td>
</tr>
<tr>
<td></td>
<td>After 5 years final follow-up, providing no residual lesions.</td>
</tr>
<tr>
<td>VSD</td>
<td>1-5 years, depending on the residual shunt</td>
</tr>
<tr>
<td>Coarctation aorta</td>
<td>Uncorrected – every year</td>
</tr>
<tr>
<td></td>
<td>After correction 2 - 3 years</td>
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<tr>
<td>AVSD</td>
<td>Every 2 years</td>
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<tr>
<td>4Fallot</td>
<td>Every 2 years</td>
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<tr>
<td>TGA with arterial switch</td>
<td>Every 2 years</td>
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<tr>
<td>Subvalvular AoS</td>
<td>Every 2 years</td>
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<tr>
<td>After Ross operation</td>
<td>Every 2 years</td>
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<tr>
<td>Marfan and aorta pathology</td>
<td>Every 2 years</td>
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<tr>
<td>Fontan</td>
<td>Every 2 years</td>
</tr>
<tr>
<td>TGA after atrial switch</td>
<td>Every 2 years</td>
</tr>
<tr>
<td>ccTGA</td>
<td>Every 2 years</td>
</tr>
</tbody>
</table>
List of Protocols

In patients where more than one defect is present a mixture of protocols will have to be used for the complete echocardiographic study

1. 1st visit at the Department of Congenital Heart Disease
2. Shunt at atrial level. 1st visit at the Department of Congenital Heart Disease
3. a. 1st echo after ASDII/PFO device closure
   b. ASD postoperative or device closure evaluation
4. a. Postoperative Evaluation CAVSD or PAVSD
   b. Postoperative Evaluation CAVSD or PAVSD short echo
5. a. Mitral Valve Disease
   b. Mitral valve repair or mechanical valve
6. a. Aortic Valve Disease (AS/AR, Marfan, Ehler-Danlos etc.)
   b. Aortic Valve Disease short protocol
7. Aortic Valve disease Postoperative follow up.
8. a. Coarctation 1st echo after stent placement and/or surgical correction
    b. Coarctation follow-up after stent placement or surgical correction
    b. Mild PS/PR pre and post operation (native or post op)
11. a. Evaluation Shunt at ventricular level
    b. Postoperative Evaluation VSD or Open ductus Botalli
12. a. Postoperative Evaluation TGA: Atrial Switch (Mustard/Senning. With or without stent)
    b. Postoperative Evaluation TGA short protocol
13. Discordant AV and VA connections
   
   b. Post operative evaluation TGA Arterial Switch short echo

15. a. Rastelli operation (TGA/VSD/DORV)
   
   b. Rastelli operation (TGA/VSD/DORV) short protocol

16. a. Fontan or Norwood procedure
   
   b. Fontan or Norwood procedure short echo

17. a. Ebstein’s Anomaly
   
   b. Ebstein’s Anomaly Post operative evaluation short echo

18. Eisenmenger’s Syndrome

19. a. Tricuspid valve disease
    
    b. Tricuspid valve repair or mechanical valve
Protocol: New patient (1st visit at the department of Congenital Heart Disease)

1. Subcostal SAX colour compare IVC. Abd. Aorta
2. Subcostal LAX gray scale IVC-connection to RA including sniff test
3. Subcostal LAX PW Doppler Hepatic vein
4. Subcostal LAX colour and PW Doppler Abd. Aorta
5. Subcostal 4CH gray scale
   (RA/RV dilatation move to protocol 2 point 4)
6. Apical 4CH focus AV connections and dimensions (measurements: RA/RV/LA)
7. Apical 4CH posterior angulation grey scale: coronary sinus
8. Apical 4 CH colour: PW pulmonary vein/mitral/TDI septum. CW mitral regurgitation
9. Apical 5CH colour compare LVOT/Aorta. CW: Vmax aorta + AR + P½t
   (PW LVOT only if aortic velocity > 2.0m/s)
10. Apical 4CH colour. + CW tricuspid regurgitation
11. Apical 4CH gray scale focus RV. TAPSE
12. Modified apical 4CH gray scale focus RV. (RV Fractional area change %)
13. Apical 4CH gray scale focus LV
14. Apical 2CH gray scale focus LV
15. Apical 2CH gray scale (LV + LA)
16. Apical 3CH gray scale focus LV
17. Apical 3CH colour/CW aorta: Vmax + AR + P½t (PW LVOT if aortic velocity > 2.0m/s)
18. Parasternal LAX gray scale 2D, still frame end-diastolic LV diameter and wall thickness
19. Parasternal LAX gray scale still frame end-systolic LV diameter
20. Parasternal LAX Aorta and LA
21. Parasternal LAX Sinus- STJ-Ascendens (3-4cm above valve) dimensions (end diastolic)
22. Parasternal LAX colour mitral regurgitation
23. Parasternal LAX colour aortic regurgitation
24. Parasternal LAX RV inflow colour + CW tricuspid regurgitation.
25. Parasternal LAX RVOT colour compare PW/CW (outflow + regurgitation)
26. Parasternal SAX mid-papillary level gray scale
27. Parasternal SAX mitral valve level gray scale and colour
28. Parasternal SAX aortic valve level gray scale
29. Parasternal SAX colour aortic/tricuspid regurgitation/RVOT
30. Parasternal SAX gray scale: pulmonary artery and branches
31. Parasternal SAX colour pulmonary artery and branches
32. Parasternal SAX CW pulmonary valve + regurgitation

(PW: RVOT if PV velocity > 1.5m/sec)
33. Suprasternal LAX aortic arch/descending aorta grey scale
34. Suprasternal LAX descending aorta colour/PW
35. Suprasternal LAX left pulmonary artery colour compare
36. Suprasternal LAX right pulmonary artery colour compare
37. Right supraclavicular LAX colour compare/PW Superior Vena Cava
2. Protocol: Shunt at Atrial Level

1. Subcostal LAX gray scale IVC-connection to RA including sniff test
2. Subcostal LAX PW Doppler Hepatic vein
3. Subcostal 4CH colour: localize defect and direction of shunt
4. Subcostal 4CH gray scale: measure Septal Defect and its rims
5. Subcostal 4CH superior angulation IAS-SVC continuation grey scale
6. Subcostal 4CH superior angulation colour: Sinus Venosus defect / RUPV
7. Subcostal SAX gray scale + colour measure defect and rims
8. Apical 4CH focused AV connections and dimensions
   (measurements: RA/RV/LA/ IAS length /defect /rims)
9. Apical 4CH posterior angulation grey scale: coronary sinus
10. Apical 4CH colour and PW: pulmonary vein x 3/mitral/TDI septum/defect
11. Apical 5CH view colour compare LVOT/Aorta. CW aorta Vmax + AR + P½t
    (PW LVOT if aortic velocity >2.0m/s)
12. Apical 4CH colour + CW tricuspid regurgitation
13. Apical 4CH gray scale focus RV. TAPSE
14. Modified apical 4CH gray scale focus RV. (RV fractional area change %)
15. Apical 4CH gray scale focus LV
16. Apical 2CH gray scale (LV + LA)
17. Apical 2 CH gray scale focus LV
18. Apical 3CH gray scale focus LV
19. Apical 3CH colour/CW aorta Vmax + P½t (PW LVOT if aortic velocity > 2.0m/s)
20. Parasternal foreshortened 4CH colour compare: localize defect and direction of shunt
22. Parasternal fore-shortened 4CH superior angulation colour for Sinus Venosus Defect

23. Parasternal LAX gray scale 2D, still frame end-diastolic LV diameter and wall thickness
24. Parasternal LAX gray scale still frame end-systolic LV diameter
25. Parasternal LAX Aorta and LA
26. Parasternal LAX colour mitral regurgitation
27. Parasternal LAX colour aortic regurgitation
28. Parasternal LAX RV inflow grey scale
29. Parasternal LAX RV inflow colour + CW tricuspid regurgitation
30. Parasternal LAX RVOT grey scale
31. Parasternal LAX RVOT colour/PW/CW (out flow + regurgitation)
32. Parasternal SAX basal level gray scale
33. Parasternal SAX apical level gray scale
34. Parasternal SAX aortic valve level gray scale
35. Parasternal SAX colour/CW/PW: aortic/tricuspid regurgitation/LLPV and LUPV /RVOT
36. Parasternal SAX colour compare pulmonary artery and branches
37. Parasternal SAX CW pulmonary valve + regurgitation

(PW RVOT if PV velocity > 1.5m/sec)

38. Suprasternal LAX gray scale aortic arch/descending aorta
39. Suprasternal LAX colour/PW descending aorta
40. Suprasternal LAX colour compare left pulmonary artery
41. Suprasternal LAX gray colour compare right pulmonary artery
42. Suprasternal LAX crab view colour compare all pulmonary veins
43. Right Supraclavicular LAX colour compare/PW Superior Vena Cava
44. (Low Right parasternal 4CH inter atrial septum)

45. (3D: Focus ASD)
(3D: Focus RV volume + ejection fraction)
3A. Protocol: 1st echo after ASDII/PFO device closure

1. Subcostal 4CH gray scale: device à vue
2. Subcostal 4CH colour: IAS
3. Subcostal SAX view gray scale
4. Subcostal SAX view colour: IVC/SVC/IAS
5. Apical 4CH gray scale
6. Apical 4CH colour inflow RUPV/mitral and tricuspid valve/IAS
7. Apical 5CH view colour Aortic regurgitation
8. Parasternal foreshortened 4CH gray scale
9. Parasternal foreshortened 4CH colour RUPV/mitral/tricuspid/IAS
10. Pericardial effusion: Protocol PE
3B. Protocol: ASD postoperative or device closure evaluation

1. Subcostal VCI gray scale, including “sniff test”
2. Subcostal 4CH colour compare IAS
3. Apical 4CH focus AV connections and dimensions (measurements RA/RV/LA)
4. Apical 4CH colour. PW mitral/TDI septum/RUPV inflow
5. Apical 4CH colour + CW tricuspid regurgitation
6. Apical 4CH gray scale focus RV. TAPSE
7. Modified apical 4CH gray scale focus RV. (RV fractional area change %)
8. Apical 4CH gray scale focus LV
9. Apical 2CH gray scale focus LV
10. Apical 2CH gray scale (LV + LA)
11. Apical 3CH gray scale focus LV
12. Apical 3CH colour/CW aorta: Vmax + AR - P½t
13. Parasternal LAX gray scale
14. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness
15. Parasternal LAX gray scale still frame end-systolic LV diameter
16. Parasternal SAX basal level gray scale
17. Parasternal SAX apical level gray scale
18. Parasternal fore-shortened 4CH colour: IAS/tricuspid regurgitation. CW for TR velocity
19. Parasternal SAX pulmonary artery colour and CW (regurgitation)
4A. Protocol: CAVSD or PAVSD Postoperative Evaluation

1. Subcostal VCI gray scale, including “sniff test”
2. Apical 4CH focused AV connections and dimensions (measurements: RA/RV/LA)
3. Apical 4CH colour and CW/PW left sided AV valve (measure E, A, DET)
   **If E-wave >1.2m/sec:** CW Doppler (measure MPG)
4. Apical 4CH colour/CW right sided AV valve regurgitation
5. Apical 4CH gray scale focus RV/TAPSE
6. Modified apical 4CH gray scale focus RV. (*RV fractional area change %)*
7. Apical 4CH gray scale focus LV
8. Apical 2CH gray scale focus LV
9. Apical 2CH gray scale (LV + LA)
10. Apical 3CH gray scale focus LV
11. Apical 3CH colour Left AV regurgitation
12. Apical 3CH colour/CW aorta: Vmax + AR + P½t
   **(PW LVOT if aortic velocity >2.0m/s)**
13. Parasternal LAX gray scale
14. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness
15. Parasternal LAX gray scale still frame end-systolic LV diameter
16. Parasternal LAX colour left AV valve regurgitation
17. Parasternal SAX mid-papillary level gray scale
18. Parasternal SAX Left AV valve level gray scale and colour
19. Parasternal SAX/colour/PW/CW pulmonary valve + regurgitation

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20. If suspected moderate-to-severe Left AV valve regurgitation

Systolic reversal in RUPV and RLPV

(Automated 3D EF if possible)
4B. Protocol: Short Echo; CAVSD or PAVSD Postoperative Evaluation

Mild left sided AV valve regurgitation no rest shunt

1. Subcostal VCI gray scale, including “sniff test”
2. Apical 4CH gray scale
3. Apical 4CH colour + CW left sided AV valve measurements
4. Apical 4CH gray scale focus LV
5. Apical 2CH gray focus LV
6. Parasternal LAX gray scale
7. Parasternal LAX colour left AV valve regurgitation
8. Parasternal fore-shortened 4CH colour/CW: right sided AV regurgitation
9. Parasternal SAX pulmonary artery + regurgitation PW/CW
5A. Protocol: Mitral Valve Disease

1. Subcostal VCI gray scale, including “sniff test”
2. Apical 4CH gray scale LV + LA
3. Apical 4CH colour mitral regurgitation jet in LA
4. Apical 4CH ZOOM vena contracta width
5. Apical 4CH ZOOM PISA (Nyquist baseline shift 38cm/sec)
6. Apical 4CH CW mitral regurgitation
7. Apical 4CH PW: transmitral flow (measure E, A, DET)
   If E-wave > 1.2m/sec: CW Doppler: mitral inflow measure MPG. P½t.
   If > moderate MR suspected: systolic flow reversal in right upper and lower pulmonary veins
8. If mean gradient>5mmHg and /or MVA<2.0cm²and/or at least moderate MR
   - Colour/CW tricuspid regurgitation jet from one good window
9. Apical 2CH gray scale LV + LA
10. Apical 2CH colour mitral regurgitation in LA
11. Apical 3CH gray scale
12. Apical 3CH colour mitral regurgitation jet in LA
13. Apical 3CH ZOOM vena contracta width
14. Apical 3CH ZOOM PISA (Nyquist baseline shift 38cm/sec)
15. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness
16. Parasternal LAX gray scale still frame end-diastolic and end-systolic LV dimensions
17. Parasternal LAX LA dimension (end systolic)
18. Parasternal LAX colour mitral regurgitation
19. Parasternal LAX ZOOM vena contracta width
20. Parasternal SAX mitral valve level gray scale
21. Parasternal SAX colour mitral regurgitation
22. *If more than moderate MR suspected and asymptomatic:* automated 3D ejection fraction + 3D LA volume
5B. Protocol: Mitral valve repair or Mechanical Valve

1. Subcostal VCI gray scale, including "sniff test"
2. Apical 4CH gray scale
3. Apical 4CH mitral inflow PW and CW Doppler (including DET and mean PG)
4. If mechanical valve: AP4CH CW Doppler (MR signal)
5. Apical 4CH colour mitral regurgitation
6. Apical 4CH colour + CW tricuspid regurgitation
7. Apical 2CH gray scale
8. Apical 2CH colour mitral regurgitation
9. Apical 3CH gray scale
10. Apical 3CH colour mitral regurgitation jet in LA
11. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness
12. Parasternal LAX gray scale still frame end-systolic LV diameter
13. Parasternal LAX colour mitral regurgitation
14. Parasternal RV inflow colour + CW tricuspid regurgitation.
### 6A. Protocol: Aortic Valve Disease (AS/AR, Marfan’s syndrome, Ehler-Danlos etc)

**Moderate to severe Aortic Stenosis / Aortic Regurgitation**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
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<tbody>
<tr>
<td>1.</td>
<td>Subcostal VCI gray scale, including “sniff test”</td>
</tr>
<tr>
<td>2.</td>
<td>Apical 4CH gray scale</td>
</tr>
<tr>
<td>3.</td>
<td>Apical 4CH colour: MR jet. PW mitral valve inflow (measure E, A, DET)</td>
</tr>
<tr>
<td>4.</td>
<td>Apical 5CH PW LVOT (VTI)</td>
</tr>
<tr>
<td>5.</td>
<td>Apical 5CH Aortic velocity mean and peak (Subvalv.AS, PW + HPRF from LVOT)</td>
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<tr>
<td>6.</td>
<td>Apical 5CH colour AR jet /CW Doppler: (P½t)</td>
</tr>
<tr>
<td>7.</td>
<td>Apical 4CH gray scale focus LV</td>
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<tr>
<td>8.</td>
<td>Apical 2CH gray scale focus LV</td>
</tr>
<tr>
<td>9.</td>
<td>Apical 3CH gray scale focus LV</td>
</tr>
<tr>
<td>10.</td>
<td>Apical 3CH aortic velocity peak and mean gradient</td>
</tr>
<tr>
<td>11.</td>
<td>Apical 3CH AR jet colour</td>
</tr>
<tr>
<td>12.</td>
<td>Apical 3CH CW Doppler AR jet (density + P½t)</td>
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<tr>
<td>13.</td>
<td>Parasternal LAX gray scale</td>
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<tr>
<td>14.</td>
<td>Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness</td>
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<tr>
<td>15.</td>
<td>Parasternal LAX gray scale still frame end-systolic LV diameter</td>
</tr>
<tr>
<td>16.</td>
<td>Parasternal LAX Annulus-Sinus-STJ-Ascendens (3-4 cm above valve) dim. (end diastolic)</td>
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<tr>
<td>17.</td>
<td>Parasternal LAX gray scale <strong>ZOOM</strong> LVOT. Still frame mid-systole LVOT diameter</td>
</tr>
<tr>
<td>18.</td>
<td>Parasternal LAX colour AR jet <strong>ZOOM</strong> vena contracta + jet width in LVOT</td>
</tr>
<tr>
<td>19.</td>
<td>Parasternal LAX colour MR</td>
</tr>
<tr>
<td>21.</td>
<td>Parasternal SAX colour compare aortic regurgitation</td>
</tr>
<tr>
<td>22.</td>
<td>Parasternal SAX basal level gray scale</td>
</tr>
</tbody>
</table>
23. Parasternal SAX apical level gray scale

24. Right Parasternal aortic velocity, peak/mean gradient (if higher than apical)

25. Suprasternal LAX aortic velocity, peak/mean gradient (if higher than apical)

26. Suprasternal: Aorta dimensions in Marfan and Ehler-Danlos

27. Suprasternal LAX Desc. Aorta CW/PW

28. Subcostal LAX PW Doppler Ao.Abd. flow reversal

29. If severe asymptomatic AS (>4m/sec): automated 3D ejection fraction and wall mass
### 6B. Protocol: Short Echo; Aortic Valve Disease (Marfan’s syndrome, Ehler-Danlos etc)

Mild aortic regurgitation follow-up (no AS)

1. Apical 4CH grey scale focus LV
2. Apical 4CH colour: MR jet. PW mitral valve inflow (measure E, A, DET)
3. Apical 5CH gray scale
4. Apical 5CH colour AR jet /CW Doppler (P½t)
5. Apical 2CH gray scale focus LV
6. Apical 3CH gray scale focus LV
7. Apical 3CH colour AR: CW Doppler: Vmax AO. AR (P½t)
8. Parasternal LAX gray scale
9. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness
10. Parasternal LAX gray scale still frame end-systolic LV diameter
11. Parasternal LAX Annulus-Sinus-STJ-Ascendens (3-4cm above valve) dim. (end diastolic)
12. Parasternal LAX colour aortic regurgitation/mitral regurgitation
13. Suprasternal: Aorta dimensions in Marfan and Ehler-Danlos

1. Subcostal VCI gray scale, including “sniff test”
2. Apical 4CH gray scale focus LV
3. Apical 4CH gray scale (ROSS procedure: RA/RV/TAPSE)
4. ROSS procedure: modified apical 4CH gray scale focus RV. RV fractional area change
5. Apical 5CH view: Aortic velocity mean and peak + acceleration time + VTI LVOT
6. Apical 5CH view colour + CW Doppler: AR (P½t)
7. Apical 2CH gray scale focus LV
8. Apical 3CH aortic velocity peak and mean gradient + acceleration time + VTI LVOT
9. Apical 3CH CW Doppler signal AR (P½t)
10. Parasternal LAX gray scale
11. Parasternal LAX Annulus-Sinus-STT-Ascendens (3- 4 cm above valve) dim. (end diastolic)
12. Parasternal LAX colour aortic regurgitation
13. ROSS procedure: Parasternal SAX Pulmonary valve inflow and colour:
   a. PW/CW localize region of stenosis. (> 3.0m/sec: mean gradient). CW for PR velocity
   b. (RVOT velocity only if PV velocity > 1.5m/sec)
8A. Protocol: Coarctation 1st echo after stent placement and/or surgical correction

1. Subcostal LAX: colour-compare Abd. Aorta
2. Subcostal LAX: PW Doppler Abd. Aorta
3. Suprasternal LAX: gray scale descending aorta stent visualization/region of operation
4. Suprasternal LAX: colour aortic descending aorta
5. Suprasternal LAX: PW pre stent/ region of operation. CW descending Aorta
8B. Protocol: Coarctation follow up after stent placement and/or surgical correction

1. Subcostal LAX: colour-compare Abd. Aorta
2. Subcostal LAX: PW Doppler Abd. Aorta
3. Apical 4CH: gray scale focus LV
4. Apical 4CH: colour mitral regurgitation
5. Apical 4CH: mitral valve inflow/septal TDI
6. Apical 5CH: colour-compare/CW Aorta (LVOT if aortic velocity >2m/s)
7. Apical 2CH: gray scale focus LV
8. Apical 3CH: gray scale focus LV
9. Apical 3CH colour AR jet (P½t)
10. Parasternal LAX: gray scale
11. Parasternal LAX: gray scale still frame end-diastolic LV diameter and wall thickness
12. Parasternal LAX: gray scale still frame end-systolic LV and LA diameter
13. Parasternal LAX annulus – sinus – STJ – asc. (3 – 4 cm above valve) dim. (end diastolic)
14. Parasternal LAX: colour aortic regurgitation
15. Parasternal SAX: mid-papillary level gray scale
16. Parasternal SAX: aortic valve level gray scale
17. Parasternal SAX: colour aortic regurgitation
18. Suprasternal LAX: grey scale descending aorta stent visualization/region of operation
19. Suprasternal LAX: colour aortic descending aorta
20. Suprasternal LAX: PW pre stent/coarct. + CW descending aorta

1. Subcostal VCI gray scale, including “sniff test”
2. Subcostal LAX PW Doppler Hepatic vein
3. Subcostal 4CH gray scale RV wall thickness, size and function
4. Apical 4CH gray scale (measurements: RA/RV/LA)
5. Apical 4CH colour /CW/PW: mitral regurgitation/mitral inflow/TDI septum (pulm.vein)
6. Apical 5CH view colour compare/PW: LVOT and Aorta
7. Apical 4CH colour + PW tricuspid inflow + CW tricuspid regurgitation
8. Apical 4CH gray scale focus RV. TAPSE + TDI lateral wall
9. Modified apical 4CH gray scale focus RV. (RV fractional area change %)
10. Apical 4CH gray scale focus LV
11. Apical 2CH gray scale focus LV
12. Apical 3CH gray scale focus LV
13. Apical 3CH colour AR jet (P½t)
14. Parasternal LAX gray scale
15. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness
16. Parasternal LAX gray scale still frame end-systolic LV diameter
17. Parasternal LAX Aorta Ascendens (3-4cm above valve) dimensions (end diastolic)
18. Parasternal LAX colour mitral regurgitation
19. Parasternal LAX colour aortic regurgitation/residual VSD + Vmax
20. Parasternal LAX RV inflow focus RV function
21. Parasternal LAX RV inflow colour + CW tricuspid regurgitation
22. Parasternal SAX basal level gray scale
23. Parasternal SAX mid-papillary level gray scale (*Ensure: RV anterior wall in sector!*)
24. Parasternal SAX apical level gray scale
25. Parasternal SAX aortic valve level colour compare/CW. aortic regurgitation + VSD Vmax
26. Parasternal SAX RVOT colour compare. Subvalv PS + pulmonary regurgitation
27. Parasternal SAX pulmonary artery/left and right branch colour compare
28. Parasternal SAX pulmonary artery CW: PV (>3.0m/sec: mean gradient)/regurgitation
   (PW RVOT velocity, only if PV velocity > 1.5m/sec)
29. High left/right Parasternal PW/CW pulmonary: homograft/conduit/percutaneous valve
30. **If moderate to severe PR**: PW Doppler RVOT and tips pulmonary valve (increase scale)
31. **If moderate to severe PR**: Suprasternal LAX LPA colour compare
32. **If moderate to severe PR**: automated 3D RV ejection fraction
33. **If Vmax TR > Vmax PV**: Exclude Peripheral PS
   a. Suprasternal LAX colour compare left pulmonary artery
   b. Suprasternal LAX colour compare right pulmonary artery
34. **By RV syst. Pressure of >40mmHg TDI RV lateral wall 100mm/sec (Tei index)**
1. Subcostal VCI gray scale, including “sniff test”
2. Subcostal LAX PW Doppler Hepatic vein
3. Apical 4CH gray scale (measurements: RA/RV/LA/TDI septum/pulm. Vein)
4. Apical 4CH colour, CW and PW: mitral/TDI septum
5. Apical 4CH gray scale focus RV: TAPSE + TDI lateral wall
6. Modified apical 4CH gray scale focus RV. (RV fractional area change %)
7. Apical 4CH gray scale focus LV
8. Apical 2CH gray scale focus LV
9. Apical 3CH gray scale focus LV
10. Parasternal LAX: gray scale still frame end-diastolic LV diameter and wall thickness
11. Parasternal LAX: gray scale still frame end-systolic LV
12. Parasternal LAX Aorta Asc. (3-4cm above valve) dimensions (end diastolic)
13. Parasternal LAX RV inflow grey scale
14. Parasternal LAX RV inflow colour + PW tricuspid inflow + CW tricuspid regurgitation
   (>TR velocity compared to previous echo report = protocol 9)
15. Parasternal SAX basal level gray scale
16. Parasternal SAX mid-papillary level gray scale focus LV and RV
17. Parasternal SAX apical level gray scale
18. Parasternal SAX pulmonary artery/left and right branch colour compare
19. PW Doppler Tips pulmonary valve (increase scale)
20. (3D: RV volume + ejection fraction if possible)
10B. Protocol: Evaluation Mild PS/PR.
Pre and Postoperative Evaluation

1. Subcostal VCI gray scale, including “sniff test”
2. Subcostal LAX PW Doppler Hepatic vein
3. Apical 4CH gray scale (measurements: RA/RV/LA)
4. Apical 4CH colour, CW and PW: mitral/TDI septum
5. Apical 4CH colour + PW tricuspid inflow + CW tricuspid regurgitation
6. Apical 4CH gray scale focus RV: TAPSE + TDI lateral wall
7. Apical 4CH gray scale focus LV
8. Apical 2CH gray scale focus LV
9. Apical 3CH gray scale focus LV
10. Apical 3CH colour aortic regurgitation + PW aortic valve
11. Parasternal LAX: gray scale still frame end-diastolic LV diameter and wall thickness
12. Parasternal LAX: gray scale still frame end-systolic LV
13. Parasternal SAX mid-papillary level gray scale
14. Parasternal SAX gray scale and colour: RVOT + MPA
15. Parasternal SAX pulmonary artery CW: Vmax + regurgitation
   a. (RVOT velocity only if PV velocity > 1.5m/sec)
   b. PV velocity > 3.0 m/sec mean gradient
16. If moderate to severe PS/PR; Follow Protocol 9/10A
11A. Protocol: Shunt at Ventricular Level

1. Subcostal VCI gray scale, including “sniff test”
2. Apical 4CH gray scale (measurements: LA)
3. Apical 4CH colour and PW: mitral inflow TDI septum
4. Apical 5CH view gray scale: LVOT and Aorta
5. Apical 5CH view colour + CW Aorta (localize Perim/subaortic VSD + AR+ P½t)
6. Apical 4CH gray scale focus LV
7. Apical 2CH gray scale focus LV
8. Apical 3CH gray scale focus LV
9. **Perim/subaotic VSD**: Apical 3CH colour aortic regurgitation
10. Parasternal LAX gray scale
11. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness
12. Parasternal LAX gray scale still frame end-systolic LV diameter
13. Parasternal LAX Aorta and LA
14. Parasternal LAX colour/CW aortic regurgitation + VSD
15. Parasternal LAX RV inflow colour + CW tricuspid regurgitation
16. Parasternal SAX mid-papillary level gray scale
17. Parasternal SAX gray scale aortic/tricuspid/RVOT
18. Parasternal SAX colour aortic/tricuspid/RVOT/ localize VSD
19. **If Vmax TR > 3m/sec.** Parasternal SAX pulmonary artery CW: PV/PR (exclude a DCRV)

**NB:**
Extra unorthodox scanning windows may be necessary to localize the origin of the shunt be it perimembranous/muscular or doubly committed

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11B. Protocol: VSD or ODB. Postoperative Evaluation

1. Subcostal VCI gray scale, including “sniff test”  
2. Apical 4CH gray scale  
3. Apical 4CH colour and PW: mitral/TDI septum  
4. Apical 5CH view colour + Aortic velocity  
5. Apical 4CH gray scale focus LV  
6. Apical 2CH gray scale focus LV  
7. Apical 3CH gray scale focus LV  
8. Parasternal LAX gray scale  
9. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness  
10. Parasternal LAX gray scale still frame end-systolic LV diameter  
11. Parasternal LAX Aorta and LA  
12. Parasternal LAX RV inflow colour + CW: tricuspid regurgitation  
13. Parasternal SAX gray scale aortic/tricuspid/RVOT  
14. Parasternal SAX colour aortic/tricuspid/RVOT (localize residual VSD)  
   a. Extra scanning windows maybe necessary to exclude a residual VSD  
15. Parasternal SAX pulmonary artery/left and right branch colour compare exclude residual duct  
16. If $V_{\text{max}}$ TR > $3 \text{m/sec}$. Parasternal SAX pulmonary artery CW: PR (exclude DCRV)
12A. Protocol: TGA Atrial Switch (Mustard/Senning and/or after stent placement) Postoperative Evaluation

1. Subcostal VCI gray scale, including “sniff test”
2. Subcostal LAX PW Doppler Hepatic vein
3. Subcostal LAX colour compare IVC-connection to LA (visualization inferior limb)
4. Subcostal 4CH gray scale (RV function and wall thickness)
5. Apical 4CH gray scale (dimensions RV). Visualization of atrial size
6. Apical 4CH colour and PW: RUPV. PVA-RA junction. TV inflow
7. Apical 4CH colour tricuspid regurgitation. CW (dP/dt increase scale 1-3m/s, speed 150mm/s)
   a. If > moderate TR suspected: systolic reversal right upper and lower pulmonary veins
8. Apical scans grey scale focus RV + TDI lateral wall (100mm/secTei index)
9. Modified apical 4 CH focus RV. (RV fractional area change %)
10. Apical 5CH gray scale (superior tilting) RV/RVOT/Aorta
11. Apical 5CH colour (superior tilting). PW/CW: Aorta Vmax. Aortic Regurgitation + P½t
12. **Apical scans**: Unorthodox planes grey scale: focus visual assessment RV function
13. Apical 4CH colour. CW, Vmax. Mitral regurgitation. PW: inferior limb from SVA baffle
14. Apical 5CH gray scale LV/LVOT/Pulmonary valve
15. Apical 5CH colour PW/CW: LVOT/Pulmonary valve and regurgitation
16. Apical 4CH gray scale focus LV
17. Apical 2CH gray scale focus LV
18. Apical 3CH gray scale focus LV
19. Apical 3CH colour/CW pulmonary regurgitation
20. Parasternal LAX gray scale focus LV
21. Parasternal LAX gray scale still frame end-diastolic LV/RV diameter and wall thickness

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22. Parasternal LAX gray scale still frame end-systolic LV diameter
23. Parasternal LAX colour mitral/pulmonary regurgitation
25. Parasternal LAX gray scale and colour aortic regurgitation
25. Higher parasternal LAX gray scale and colour superior limb from SVA baffle
26. Parasternal LAX RV inflow gray scale RV function wall thickness
27. Parasternal LAX RV inflow colour (tricuspid regurgitation CW if not seen apical 4CH)
28. Parasternal SAX mid-papillary level: gray scale LV and RV function
29. Parasternal SAX mitral valve level: gray scale LV and RV function
30. Right Supraclavicular LAX Superior Vena Cava gray scale/colour/PW
31. *(3D: RV volume + ejection fraction if possible)*
12B. Protocol: Short Echo; TGA: Atrial Switch (Mustard/Senning) and/or after stent placement. Postoperative Evaluation

1. Subcostal VCI gray scale, including “sniff test”
2. Subcostal 4CH gray scale (RV function and wall thickness)
3. Apical 4CH gray scale focused RV function and dimensions
4. Apical 4CH colour /CW/ PW: tricuspid regurgitation/ TV inflow
5. Apical scans gray scale focus RV + TDI lateral wall (100mm/secTei index)
6. Modified apical 4CH focus RV. (RV fractional area change %)
7. Apical 4CH gray scale focus LV
8. Apical 4CH colour/ CW: Vmax mitral regurgitation
9. Apical 2CH gray scale focus LV
10. Apical 3CH gray scale focus LV
11. Apical 3CH colour/CW: pulmonary regurgitation
12. Parasternal LAX gray scale
13. Parasternal SAX mid-papillary level: gray scale LV and RV function
14. Parasternal SAX mitral valve level: gray scale LV and RV function
15. (3D: RV volume + ejection fraction if possible)
13. Protocol: Discordant AV and VA connections

1. Subcostal VCI gray scale, including “sniff test”
2. Subcostal 4CH gray scale (RV function and wall thickness)
3. Apical 4CH focused AV connections and dimensions (measurements: RA/RV/LA/Right ventricle fractional area change %)
4. Apical 4CH colour/CW/ PW: tricuspid inflow + Tricuspid regurgitation ($dP/dt$ increase scale $3m/sec$ speed $100mm/sec$) + TDI septum.

   If more than moderate TR suspected: systolic reversal right upper and lower pulmonary veins
5. Apical 4CH colour/CW mitral regurgitation
6. Apical 4CH gray scale focus LV
7. Apical 5CH gray scale (superior tilting) LV/LVOT/Pulmonary valve
8. Apical 5CH colour (superior tilting) PW/CW: Vmax LVOT/PV. + Regurgitation
9. Apical 4CH gray scale focus RV + TDI lateral wall ($100mm/s$ Tei index)
10. Apical 5CH gray scale (extensive superior tilting) RVOT/Aortic valve
11. Apical 5CH colour (extensive superior tilting) PW/CW: Vmax Ao. Aortic regurgitation.
12. Apical scans: unorthodox windows: gray scale focus RV and LV visual assessment of function
13. (3D: RV volume + ejection fraction)

1. Subcostal VCI gray scale, including “sniff test”
2. Apical 4CH gray scale measurements: RA/RV/LA
3. Apical 4CH colour and PW/CW: mitral inflow + regurgitation + TDI septum
4. Apical 5CH view gray scale: LVOT and Aorta
5. Apical 5CH view colour/PW: Aorta (LVOT only if aortic velocity > 2.0m/s)
6. Apical 4CH colour + CW tricuspid regurgitation
7. Apical 4CH gray scale focus RV. TAPSE + TDI lateral wall
8. Modified apical 4CH focus RV. (RV fractional area change %)
9. Apical 4CH gray scale focus LV
10. Apical 2CH gray scale focus LV
11. Apical 3CH gray scale focus LV
12. Apical 3CH colour/ CW AR + P½t
13. Parasternal LAX gray scale
14. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness
15. Parasternal LAX gray scale still frame end-systolic LV diameter
16. Parasternal LAX Aorta and LA
17. Parasternal LAX STJ-Ascendens (3-4cm above valve) dimensions (end diastolic)
18. Parasternal LAX colour mitral regurgitation
19. Parasternal LAX colour aortic regurgitation
20. Parasternal LAX RV inflow colour + CW tricuspid regurgitation
21. Parasternal SAX basal level gray scale
22. Parasternal SAX papillary level gray scale
23. Parasternal SAX apical valve level gray scale
24. Parasternal SAX aortic valve level gray scale
25. Parasternal SAX colour aortic/tricuspid regurgitation/RVOT
26. High Parasternal SAX colour compare: pulmonary artery left and right branch
   (if the Le Compt maneuver has been performed)
27. High Parasternal SAX pulmonary artery PW/ CW (RVOT velocity only if PV Velocity > 1.5m/s)
28. (3D LV and RV volume + ejection fraction if possible)
14B. Protocol: Short Echo; TGA: Arterial switch
Postoperative evaluation

1. Subcostal VCI gray scale, including “sniff test”
2. Apical 4CH gray scale (measurements: RA/RV/LA)
3. Apical 4CH colour, and PW/CW: mitral inflow + regurgitation + TDI septum
4. Apical 4CH gray scale focus RV. TAPSE + TDI lateral wall
5. Modified apical 4CH focus RV. (*RV fractional area change %*)
6. Apical 4CH gray scale focus LV
7. Apical 2CH gray scale focus LV
8. Apical 3CH gray scale focus LV
9. Apical 3CH colour/ CW AR + P½t
10. Parasternal LAX gray scale
11. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness
12. Parasternal LAX gray scale still frame end-systolic LV diameter
13. Parasternal LAX Aorta Ascendens (3-4cm above valve) dimensions (end diastolic)
14. Parasternal LAX RV inflow gray scale/ colour + CW tricuspid regurgitation
15. Parasternal SAX basal level gray scale focus LV
16. Parasternal SAX apical level gray scale focus LV
17. (3D LV and RV volume + ejection fraction)
15A. Protocol: Rastelli operation (TGA+VSD/DORV)

1. Subcostal VCI gray scale, including “sniff test”
2. Subcostal LAX PW Doppler Hepatic vein
3. Apical 4CH gray scale measurements: RA/RV/LA
4. Apical 4CH colour and PW/CW: mitral inflow + regurgitation + TDI septum
5. Apical 5CH view gray scale: LVOT and Aorta
6. Apical 5CH view colour/PW: Aorta (LVOT only if aortic velocity > 2.0m/s)
7. Apical 4CH colour + CW tricuspid regurgitation
8. Apical 4CH gray scale focus RV. TAPSE + TDI lateral wall
9. Modified apical 4CH focus RV. (RV fractional area change %)
10. Apical 4CH gray scale focused LV
11. Apical 2CH gray scale focus LV
12. Apical 3CH gray scale focus LV
13. Apical 3CH (very lateral) colour/PW + CW: LVOT + Aorta
14. Apical 3CH (very lateral) colour/CW aortic regurgitation/ residual VSD
15. Apical 3CH (very lateral and superior tilting) colour + CW evaluation Pulmonary conduit
16. Parasternal LAX gray scale
17. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness
18. Parasternal LAX gray scale still frame end-systolic LV diameter
19. Parasternal LAX Aorta and LA
20. Parasternal LAX colour mitral regurgitation
21. Parasternal LAX colour aortic regurgitation/residual VSD
22. Parasternal LAX RV inflow colour/CW tricuspid regurgitation

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23. Parasternal SAX mid-papillary level gray scale
24. Parasternal SAX mitral valve level gray scale
25. Parasternal SAX aortic valve level gray scale
26. Parasternal SAX colour aortic/tricuspid regurgitation/RVOT
27. High (right or left) Parasternal: colour/PW/CW: RVOT/ evaluation Pulmonary conduit
28. (3D. RV volume + EF)
15B. Protocol: Short Echo; Rastelli operation (TGA+VSD/DORV)

1. Subcostal VCI gray scale, including “sniff test”
2. Apical 4CH gray scale (measurements: RA/RV/LA)
3. Apical 4CH colour, PW/CW: mitral inflow + regurgitation + TDI septum
4. Apical 4CH gray scale focus RV. TAPSE + TDI lateral wall
5. Apical 4CH gray scale focus LV
6. Apical 2CH gray scale focus LV
7. Apical 3CH gray scale focus LV
8. Parasternal LAX gray scale
9. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness
10. Parasternal LAX gray scale still frame end-systolic LV diameter
11. Parasternal LAX RV inflow gray scale/ colour/CW tricuspid regurgitation
12. Parasternal SAX mid-papillary level gray scale focus LV and RV
16A. Protocol: Fontan Procedure and Norwood
(Pulmonary atresia intact septum/tricuspid atresia/univentricular heart/HPLH)

N.B. Low velocity circulation: decrease colour Doppler scale!
Possible connections: RA-RV/RA-AP/TCPC (intra or extra-cardiac tunnel)

1. Subcostal LAX gray scale IVC-connection to RA/tunnel (spontaneous contrast)
2. Subcostal LAX colour IVC-connection to RA/tunnel (atrial shunts)
3. Subcostal LAX PW Doppler Hepatic vein (25 mm/sec for respiration effect)
4. Apical 4CH gray scale LA and RA dimensions (in TCPC: tunnel dimensions)
5. Apical 4CH colour and PW: pulmonary vein + shunts at atrial level
6. Apical 4CH colour and PW/CW: AV valve inflow + regurgitation
7. Apical 5CH view colour/PW: LVOT + Aorta
8. Apical 4CH gray scale focus ventricle
9. Apical 2CH gray scale focus ventricle
10. Apical 3CH gray scale focus ventricle
11. Apical 3CH colour/CW/PW: Aortic outflow + regurgitation
12. Parasternal LAX gray scale
13. Parasternal LAX gray scale still frame end-diastolic ventricle diameter and wall thickness
14. Parasternal LAX gray scale still frame end-systolic ventricle diameter
15. Parasternal LAX Annulus-Sinus-STJ- Ascendens (3 – 4 cm above valve) dim. (end diastolic)
16. Parasternal LAX colour AV valve regurgitation
17. Parasternal LAX colour aortic regurgitation
18. Parasternal SAX gray scale RV/RVOT (not in TCPC and RA-AP connection)
19. Parasternal SAX colour/PW: RA-RV connection or RA-AP connection (not in TCPC)
20. Parasternal SAX gray scale pulmonary artery left and right branch (not in TCPC)
21. Parasternal SAX colour pulmonary artery left and right branch (not in TCPC)
22. Parasternal SAX PW: RVOT/PA outflow + regurgitation (not in TCPC)
23. Suprasternal LAX left pulmonary artery gray scale/colour/PW
24. Suprasternal LAX right pulmonary artery gray scale/colour/PW inflow TCPC
25. Right Supraclavicular LAX Superior Vena Cava gray scale/colour/PW (Glenn circulation)
26. (3D ventricular volume + ejection fraction)
16B. Protocol: Short Echo; Fontan Procedure and Norwood Ventricular Function

(Pulmonary atresia intact septum/tricuspid atresia/ univentricular heart/HPLH)

1. Apical 4CH gray scale focus ventricle
2. Apical 4CH colour, CW and PW: AV valve inflow + regurgitation
3. Apical 4CH gray scale focus ventricle
4. Apical 2CH gray scale focus ventricle
5. Apical 3CH gray scale focus ventricle
6. Parasternal LAX gray scale
7. Parasternal LAX gray scale still frame end-diastolic ventricle diameter and wall thickness
8. Parasternal LAX gray scale still frame end-systolic ventricle diameter
9. Parasternal SAX mid-papillary level gray scale focus ventricle
10. (3D ventricular volume and ejection fraction)
17A. Protocol: Ebstein’s Anomaly

1. Subcostal VCI gray scale, including “sniff test”
2. Subcostal LAX PW Doppler Hepatic vein
3. Subcostal 4CH gray scale ventricle (displacement/tethering Tricuspid valve)
4. Subcostal 4CH colour: localize ASD and direction of shunt (Protocol 2)
5. Apical 4CH gray scale focus AV connections and dimensions (measurements: RA/RV/LA, distance between offset of mitral and tricuspid valve/assess septal TV leaflet)
6. Apical 4CH colour and PW mitral/TDI septum
7. Apical 5CH gray scale: LVOT and Aorta
8. Apical 5CH colour/CW (PW: LVOT only if aortic velocity > 2.0m/s)
9. Apical 4CH colour + CW tricuspid regurgitation
10. Modified apical 4CH focus RV. (RV fractional area change %)
11. Apical 4CH gray scale focus LV
12. Apical 2CH gray scale focus LV
13. Apical 3CH gray scale focus LV
14. Apical 3CH aortic regurgitation
15. Parasternal LAX gray scale
16. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness
17. Parasternal LAX gray scale still frame end-systolic LV diameter
18. Parasternal LAX Aorta and LA
19. Parasternal LAX colour mitral regurgitation
20. Parasternal LAX colour aortic regurgitation
21. Parasternal LAX RV inflow gray scale focus tricuspid valve (assess anterior TV leaflet)
22. Parasternal LAX RV inflow colour/CW tricuspid regurgitation
23. Parasternal LAX RV outflow tract colour compare/ PW/CW
24. Parasternal SAX mid-papillary level gray scale
25. Parasternal SAX mitral valve level gray scale
26. Parasternal SAX aortic valve level gray scale
27. Parasternal SAX colour aortic/tricuspid regurgitation/RVOT (assess posterior TV leaflet)
28. Parasternal SAX pulmonary artery colour/compare
29. Parasternal SAX pulmonary artery PW/ CW: Vmax + regurgitation

(RVOT velocity only if PV velocity > 1.5m/sec)
17B. Protocol: Short Echo; Ebstein’s Anomaly
Pre- or Postoperative Evaluation

1. Subcostal VCI gray scale, including “sniff test”
2. Subcostal LAX PW Doppler Hepatic vein
3. Subcostal 4CH Colour residual PFO/ASD/TR
4. Apical 4CH gray scale focused AV connections and dimensions (measurements: RA/RV/LA)
5. Apical 4CH colour/ PW/CW mitral/TDI septum
6. Apical 4CH colour/CW tricuspid regurgitation
7. Modified apical 4CH gray scale focus RV. (RV fractional area change %)
8. Apical 4CH gray scale focus LV
9. Apical 2CH gray scale focus LV
10. Apical 3CH gray scale focus LV
11. Apical 3CH colour aortic regurgitation
12. Parasternal LAX gray scale
13. Parasternal LAX gray scale still frame end-diastolic LV diameter and wall thickness
14. Parasternal LAX gray scale still frame end-systolic LV diameter
15. Parasternal LAX colour mitral regurgitation
16. Parasternal LAX colour aortic regurgitation
17. Parasternal LAX RV inflow colour/CW tricuspid regurgitation
   Tricuspid valve replacement/reconstruction: inflow/ mean PG
18. Parasternal SAX mid-papillary level gray scale
19. If Vmax TR > 3.0 m/sec. Parasternal SAX pulmonary artery gray/colour/CW
18. Protocol: Eisenmenger Syndrome or Primary Pulmonary Hypertension

1. Subcostal VCI gray scale, including “sniff test”
2. Subcostal LAX PW Doppler Hepatic vein
3. Apical 4CH gray scale (measurements: RA/RV/LA)
4. Apical 4CH colour and PW/CW mitral inflow + regurgitation /TDI septum
5. Apical 4CH colour + CW tricuspid regurgitation (>4m/sec: dP/dt: increase scale 3m/s, speed 100mm/sec)
6. Apical 4CH gray scale focus RV + TDI lateral wall 100mm/sec (Tei index)
7. Modified apical 4CH gray scale focus RV. (RV fractional area change %).
8. Apical 4CH gray scale focus LV
9. Apical 2CH gray scale focus LV
10. Apical 3CH gray scale focus LV
11. Parasternal LAX gray scale
12. Parasternal LAX RV inflow colour/CW tricuspid regurgitation
13. Parasternal SAX basal level gray scale
14. Parasternal SAX apical level gray scale
15. Parasternal SAX pulmonary artery: colour + PW + CW outflow + regurgitation
16. (3D RV volume and ejection fraction)
19A. Protocol: Tricuspid Valve Disease

1. Subcostal VCI gray scale, including “sniff test”
2. Subcostal LAX PW Doppler Hepatic vein
3. Apical 4CH gray scale measurements: RA/RV
4. Apical 4CH colour + CW tricuspid regurgitation jet and velocity
5. Apical 4CH gray scale focus RV TAPSE
6. Apical 4CH gray scale end-diastolic TV annulus
7. Parasternal LAX gray scale
8. Parasternal LAX gray scale still frame end-diastolic and end-systolic LV dimensions
9. Parasternal LAX RV inflow colour/CW tricuspid regurgitation + PW E-wave velocity
   a. Tricuspid stenosis CW; mean gradient.
10. Parasternal SAX gray scale aortic/tricuspid/RVOT/PV
11. Parasternal SAX colour: tricuspid regurgitation
12. Parasternal SAX colour + CW pulm. Regurg. + PW. Pulm. valve
19B. Protocol: Tricuspid valve repair or Mechanical valve

1. Apical 4CH gray scale
2. Apical 4CH colour: tricuspid inflow + mean gradient. CW for regurgitation
3. Parasternal LAX RV inflow
4. Parasternal LAX RV colour: tricuspid inflow + mean gradient. CW for regurgitation