A-Z Notes in Radiological Practice and Reporting
Series Editors: Carlo Nicola De Cecco · Andrea Laghi

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Marco Rengo

MDCT and MRI of the Heart

Springer

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Foreword to this Series

A-Z *Notes in Radiological Practice and Reporting* is a new series of practical guides dedicated to residents and general radiologists. The series was born thanks to the original idea to bring to the public attention a series of notes, collected by doctors and fellows during their clinical activity and attendance at international academic Institutions. Those brief notes were critically reviewed, sometimes integrated, cleaned up and organized in the form of an A-Z glossary, to be usable by a third reader.

The ease and speed of consultation and the agility in reading were behind the construction of this series and were the reasons why the booklets are organized alphabetically, primarily according to disease or condition. The number of illustrations has been deliberately reduced and focused only on those ones relevant to the specific entry.

Residents and general radiologists will find in these booklets numerous quick answers to frequent questions occurring during radiological practice, which will be useful in daily activity for planning exams and radiologic reporting.

Each single entry typically includes a short description of pathological and clinical characteristics, guidance on selection of the most appropriate imaging technique, a schematic review of potential diagnostic clues, and useful tips and tricks.

The series will include the most relevant topics in radiology, starting with cardiac imaging and continuing with the gastrointestinal tract, liver, pancreas and bile ducts and genitourinary apparatus during the first two years. More arguments will be covered in the next issues.

The Editors put a lot of their efforts in selecting the most appropriate colleagues willing to exchange with readers their own experiences in their respective fields. The result is a combination of experienced professors, enthusiastic researchers and young talented radiologists working together within a single framework project, with the primary aim of making their knowledge available for residents and general practitioners.

We really do hope that this series can meet the satisfaction of the readers and can help them in their daily radiological practice.

Latina, Italy

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Contents

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Abbreviations

4CH	Four-chamber view
ALCAPA	Anomalous LCA from pulmonary artery
ARCAPA	Anomalous RCA from pulmonary artery
ARVC	Arrhythmogenic right ventricular cardiomyopathy
ASD	Atrial septal defect
AV	Atrioventricular
AVM	Arteriovenous malformation
AVSD	Atrioventricular septal defect
BB	Black blood
BMI	Body mass index
BSA	Body surface area
CAD	Coronary artery disease
CCTA	Coronary CT angiography
CEMRA	Contrast-enhanced magnetic resonance angiography
CRT	Cardiac resynchronization therapy
CT	Computed tomography
CTA	CT angiography
CTDI	CT dose index
DLP	Dose length product
DVT	Deep vein thrombosis
ECG	Electrocardiography

EDV	End-diastolic volume
EG	Early gadolinium
FA	Flip angle
FDR	First-degree relatives
FFR	Fraction glow reserve
FLASH	Fast low angle shot
GCA	Giant cell arteritis
GFR	Glomerular filtration rate
HR	Heart rate
ICD	Implantable cardioverter defibrillator
IHD	Ischemic heart disease
IMH	Intramural hematoma
IP-PC	In-plane phase contrast
iRVEDV	Indexed right ventricle end-diastolic volume
IVC	Inferior vena cava
LA	Left atrium
LAS	Low amplitude signal
LBBB	Left bundle branch block
LBI	Left bundle inferior
LCA	Left coronary artery
LCX	Left circumflex artery
LE	Late enhancement
LIMA	Left internal mammary artery
LM	Left main
LP	Late potential
LV	Left ventricle
LVA	Left ventricular assist device
LVIT	Left ventricle inflow tract
LVOT	Left ventricle outflow tract
LVSV	Left ventricle stroke volume
MAPCAs	Major aortopulmonary collateral arteries
MI	Myocardial infarction
MIP	Maximum intensity projection
MPA	Main pulmonary artery

MR	Magnetic resonance
NSF	Nephrogenic systemic fibrosis
NSVT	Nonsustained ventricular tachycardia
NYHA	New York Heart Association
PAH	Pulmonary arterial hypertension
PC	Phase contrast
PCI	Percutaneous coronary intervention
PE	Pulmonary embolism
PET	Positron emission tomography
PFO	Patent foramen ovale
PMK	Pacemaker
PV	Pulmonary vein
RA	Right atrium
RBBB	Right bundle branch block
RCA	Right coronary artery
RIMA	Right internal mammary artery
RMS	Root mean square
ROI	Region of interest
RPA	Right pulmonary artery
RV	Right ventricle
RVOT	Right ventricle outflow tract
RVSV	Right ventricle stroke volume
SAECG	Signal-averaged electrocardiography
SAM	Systolic anterior movement
SAR	Specific absorption rate
SD	Sudden death
SI	Signal intensity
SLE	Systemic lupus erythematosus
SPECT	Single-photon emission computed tomography
SSFP	Steady-state free precession
STIR	Short TI inversion recovery
SVC	Superior vena cava
SVG	Single vessel graft
TAD	Terminal activation duration

TAPVR	Total anomalous pulmonary venous return
TAS	Transaxial cine stack
TCPC	Total cavopulmonary connection
TDI	Tissue doppler imaging
TE	Echo time
TFC	Task force criteria
TGA	Transposition of great arteries
TI	Inversion time
TOE	Transesophageal echocardiography
ToF	Tetralogy of fallot
TP-PC	Through-plane phase contrast
TR	Repetition time
TTE	Transthoracic echocardiography
VENC	Velocity encoded
VLA	Vertical long axis
VPS	View per segment
VSD	Ventricular septal defect
VT	Ventricular tachycardia
W/L	Weight/length
WHO	World Health Organization

A

Acute Coronary Syndrome

- Term used to describe a constellation of symptoms resulting from acute myocardial ischemia.
- Two major groups: (1) ST elevation myocardial infarct (STEMI) and (2) non-ST elevation myocardial infarction (NSTEMI and unstable angina).
- Treatments: (1) STEMI, reperfusion therapy; (2) NSTEMI, not treated with thrombolysis.

Adenosine

- Vasodilator agent used in myocardial stress perfusion.
- Most commonly used stress agent due to its ultrashort half-life (<10 s).
- Dose: 140 μg/kg/min for 3–6 min.
- Caffeine or other methylxanthines should be avoided for 24 h before the administration.

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- Contraindications: (1) high-grade AV block; (2) asthma or COPD; (3) sinus bradycardia; (4) systemic hypotension (BP < 90 mmHg); (5) severe carotid stenosis.
- Side effects: transient heart block, transient hypotension, transient tachycardia, bronchospasm.
- Antagonist: aminophylline, 50–100 mg over 1 min, injection can be repeated up to 250 mg total dose.
- See also "Perfusion imaging, myocardial".

ALARA

- Procedures that utilize ionizing radiation should be performed according to the As Low As Reasonably Achievable (ALARA) principles, and physicians prescribing and performing cardiac imaging should be very confidential with the radiation dose delivered and strategies able to minimize radiation dose exposure.

Alcohol Septal Ablation

- HCM treatment in patients with severe LVOT dynamic obstruction consisting in the injection of alcohol into the septal perforator arteries to induce localized infarct of the hypertrophied segment.
- Complications: AV block and increased risk of ventricular arrhythmias.

Amyloidosis, Cardiac

- *Characteristics*: (1) deposition of amyloid protein in any organ; (2) hereditary or acquired; (3) cardiac involvement frequent in primary AL amyloid including myeloma and

lymphoma; rare in AA amyloid secondary to chronic infection.
- *MR*: (1) LV concentric hypertrophy, heart failure (restrictive pattern with atrial dilatation followed by systolic dysfunction); (2) LE, subendocardial ring pattern or diffuse transmural pattern, involves both ventricles; (3) in late enhancement, can be difficult to suppress the myocardial signal due to extensive amyloid deposition.
- *Differential diagnosis*: hypertrophic cardiomyopathy, Anderson–Fabry disease, hypertensive hypertrophy.
- *Tips and tricks*: Amyloidosis is associated with renal failure; look for renal morphological alteration using coronal single-shot turbo spin-echo sequence with large FoV.

Anderson–Fabry Disease

- *Characteristics*: X-linked lysosomal storage disease for the lack of alpha-galactosidase A.
- *MR*: (1) LV concentric hypertrophy; (2) intramural LE (inferolateral wall); (3) valvular thickening (aortic and mitral); (4) conduction abnormalities.
- *Differential diagnosis*: hypertrophic cardiomyopathy, amyloidosis, sarcoidosis, hypertensive hypertrophy.

Angina

- Chest pain caused by myocardial ischemia.
- Causes: coronary stenosis, tachycardia, anemia, aortic stenosis, left ventricular hypertrophy, syndrome X, coronary artery spasm.
- Classification: (1) stable angina, pain occurring after constant level of exercise; (2) unstable angina, pain on minor exercise or at rest which is of new onset or a worsening angina.

Angiosarcoma

- Most common primary cardiac malignant tumor.
- Two forms: (1) focal, usually in the right atrium; (2) diffuse, with pericardial infiltration.
- *MR*: heterogeneous intracardiac mass with extensive myocardial infiltration.

Aorta, Thoracic

- Aortic values should be normalized for patient BSA.
- A diameter >40 mm for ascending aorta is considered dilated.
- Ascending aorta should be less than twice the diameter of the descending.
- *CT*/*MR*: To accurately evaluate ascending aorta and aortic annulus dimensions, use cardiac gating.

Aortic Aneurysm, Thoracic

- Surgical repair should be considered in (1) asymptomatic patients with ascending aorta or aortic sinus diameter >5.5 cm, (2) patients with Marfan syndrome or other genetically mediated disorders (vascular Ehlers–Danlos syndrome,

Table 1 Normal adult thoracic aorta diameters

Thoracic aorta diameters	
	Range (cm)
Root female	3.50–3.72
Root male	3.63–3.91
Ascending female, male	2.68
Mid-descending female	2.45–2.64
Mid-descending male	2.39–2.98

Turner's syndrome, bicuspid aortic valve, or familial thoracic aortic aneurysm and dissection) with ascending aorta or aortic sinus diameter >4.0 or 5.0 cm depending on the condition, (3) patients with a growth rate of more than 0.5 cm/year in an aorta that is less than 5.5 cm, and (4) patients undergoing aortic valve repair or replacement and who have an ascending aorta or aortic root >4.5 cm should be considered for concomitant repair of the aortic root or replacement of the ascending aorta.

- Impending signs of rupture: (1) Maximal diameter, the most important factor to predict likelihood of aneurysmal rupture; of patients suffering for aneurysms >5 cm, an aneurysmal rupture within 5 years has a likelihood of 25–41 %; a 5–7 cm and >7 cm sized aneurysms have annual risks of rupture of 6–11 % and 20 %; (2) expansion rate, if higher than 1 cm/6 months, might be a reasonable criterion of impending rupture, and an enlargement rate of 10 mm or more per year is also considered as an indication for surgical repair; (3) hyperdense aortic wall crescent, appreciated on unenhanced CT and represents an internal dissection of blood into the peripheral thrombus or into aneurysm wall; (4) infected aneurysm, more prone to rupture (rate of 53–75 % at surgical repair); (5) thrombus and calcification, thick circumferential thrombus has a protective value against rupture, and a focal discontinuity in circumferential wall calcifications is more commonly observed in unstable or ruptured aneurysms.

Aortic Arch, Cervical

- Congenital variant in which the aortic arch course is higher than normal and lies behind the left clavicle.
- Clinical consequences if central venous cannulation is required.

Aortic Arch, Right Sided

- Congenital variant with the thoracic aorta lying on the right side (0.5 % of population).
- Abdominal aorta usually normal.
- No clinical consequences.

Aortic Bleb

- Focal transverse outpouching of the aortic wall.
- Impending sign of aneurysm rupture.
- *CT*: use multiplanar reconstruction and volume rendering algorithm to detect aortic bleb.

Aortic Bovine Arch

- The left common carotid artery has a common origin with the innominate artery.
- A similar but less common variant occurs when the left common carotid artery originates directly from the innominate artery rather than as a common trunk.
- No clinical consequences.

Aortic Coarctation

- Narrowing of the aorta just distal to the left subclavian artery due to ductus arteriosus abnormalities and remnants.
- Isolated or in combination with other anomalies (bicuspid aortic valve, VSD, mitral disease, intracranial aneurysms, Turner's syndrome, Shone's syndrome).
- Discrete or segmental.

- Poststenotic dilatation of the proximal descending aorta.
- Always look at the transverse arch caliber (exclude hypoplasia) and branches, particularly the position of the left subclavian artery related to the site of coarctation.
- 50 % patients with bicuspid aortic valve.
- Aortic coarctation and bicuspid aortic valve are considered by many authors as a diffuse aortopathy.
- In native severe coarctation the amount of flow at the level of minimum caliber is very low and there might be no pressure gradient. This is in keeping with dominant collateral flow.
- Maximum gradient >20 mmHg indicates need for surgical treatment.
- *Postsurgical complications*: (1) isthmic aneurysms; (2) recoarctation, maximum gradient >20 mmHg; (3) endocarditis; (4) bicuspid aortic valve: ascending aorta dilatation; (5) intracranial arterial aneurysms; (6) coronary artery disease.
- *MR*: (1) Use black blood imaging on the arch ("candle stick" view), particularly for stents; (2) "diastolic tail" is a sign of coarctation with competent aortic valve and good elastance of the thoracic aorta; (3) flow of the descending aorta at the diaphragm in through plane with "diastolic tail"; the aortic valve must be competent; (4) peak velocity measured with a through-plane flow immediately after the site of maximum stenosis; (5) quantification of collaterals by measuring flow volume of descending aorta at the level of coarctation and at the diaphragm. In normal subject a flow reduction is observed due to orthodromic outflow in intercostal arteries. In coarctation there is a flow increment for the presence of retrograde inflow from the intercostal arteries; (6) reporting: site, morphology, extension, gradient, collaterals, LV function and dimensions (hypertrophy), mitro-aortic disease.
- *CT*: can be useful in postsurgical evaluation, stent, and coronary assessment.
- *Differential diagnosis*: (1) pseudocoarctation, tortuous aorta without stenosis; (2) hypoplastic aortic arch, with or without coarctation.

Aortic Dissection

- Stanford classification: (1) Type A: involves the ascending aorta and/or aortic arch and possibly the descending aorta. The tear can originate in the ascending aorta, in the aortic arch, or in the descending aorta. Requires primary surgical treatment because ascending aortic dissections often involve the aortic valve; (2) type B: involves the descending aorta or the arch (distal to right brachiocephalic artery origin), without involvement of the ascending aorta. Medically as initial treatment with surgery reserved for any complications.
- *CT*: It is a fast noninvasive test that will give an accurate three-dimensional view of the aorta.
- *MR*: Time-consuming procedure with inferior spatial resolution. Second-line technique. Useful in postsurgical follow-up.

Aortic Valve

- Normal annulus area: 2 cm^2 in adults, varying from 2.5 to 4.0 cm^2.
- *CT*: Planimetry is best achieved in axial MIP reformatted image during midsystole (approximately 20 % of the R-R interval or 50–100 ms from the R-wave peak depending on heart rate) to minimize artifacts.
- *MR*: (1) LVOT (oblique axial) and LVIT/OT (oblique coronal) views; (2) short axis through aortic valve cusps, perpendicular to both the precedent views and at the level of the tips; (3) planimetry is achieved in an imaging plane through the valve tips in systole and acquiring multiple thin (4–5 mm) slices parallel to the valve orifice.

Aortic Valve, Bicuspid

- The most common congenital cardiac defect (1–2 % of population).
- Two types: (1) two morphological and functional cusps and (2) three cusps, two of which are fused to a single aberrant one with the development of a raphe.
- Association with aortic coarctation, PDA, and coronary artery anomalies.
- Dilatation of sinus of Valsalva and ascending aorta.
- *CT*: Can be difficult to differentiate the two types, because at diastole the raphe can be mistaken as a normal commissure. Reconstructions during systole are required.
- *MR*: Permits to visualize the aortic valve morphology in axial image in systole. For quantification velocity mapping in systole shows the forward flow and peak velocity.

Aortic Valve, Regurgitation

- Causes: (1) valvular (the cusps are thickened and shortened); (2) secondary to dilatation of the aortic annulus; (3) secondary to aortic dissection.
- *CT*: (1) Coronal MIP reformatted image obtained during diastole; (2) malcoaptation of the cusps is well visualized during mid- to end diastole; (3) measure the regurgitant orifice.
- *MR*: (1) Jet is best visualized in the coronal or oblique coronal plane on cine imaging; (2) ensure that the image slice is at the magnet isocenter to minimize quantification errors.
- *Quantitative Flow Measurements*
  - Through-plane velocity mapping above the valvular plane, best if between the coronary ostia and the aortic valve; in order to ensure that the velocity vectors for the majority

flow are through plane in this image, it is best to use two perpendicular images through the ascending aorta and prescribe the oblique axial plane perpendicular to both.
- In isolated aortic regurgitation, set a through-plane velocity window of ±1.5 m/s; if significant aortic stenosis is present a dual velocity window may be necessary, with a high systolic setting of ±5 m/s, changing to ±1.5 m/s for the diastolic frames.
- Flow stream measurements are more precise when the aortic root is not dilated and is immobile, for example, after surgery.
- To estimate the velocity precisely, excursion height and lumen diameter should be measured, because of the underestimation of aortic regurgitation related to a combination of the movement of the aortic valve and elastic expansion of the aortic sinuses and root (aortic wall distensibility).
- Regurgitant volume is the amount of retrograde diastolic flow and is measured in ml/beat.
- Regurgitant fraction (%): aortic retrograde flow (ml/beat)/aortic forward flow (ml/beat) × 100.
- If flow quantification cannot be performed, regurgitant volume could be assessed with LV and RV stroke volume (LVSV–RVSV), but this is less direct and relies on the lack of any other valve regurgitation or shunt.
- An approximate assessment of the severity of aortic regurgitation can also be obtained by the visualization of the signal void of the regurgitant jet on cine imaging, but this method is subject to many potential errors and is not recommended for accurate evaluation:
    - Grade 1: signal loss close to the valve.
    - Grade 2: signal loss extending into the proximal chamber.
    - Grade 3: signal loss filling the whole of the proximal chamber.
    - Grade 4: signal loss in the receiving chamber throughout the relevant half of the cardiac cycle.

Table 2 Degree of aortic valve regurgitation

Aortic valve regurgitation		
Degree	Regurgitation fraction (%)	Regurgitation volume (ml/beat)
Mild	<30	<30
Moderate	30–49	30–59
Severe	≥50	≥60

Aortic Valve, Stenosis

- Three types of aortic stenosis: (1) valvular (congenital or acquired), (2) subvalvular (fibrous membrane or muscular hypertrophy), and (3) supravalvular.
- Patients are usually asymptomatic until the stenosis reduces the aortic valve area to 1 cm^2.
- Evaluation of leaflet morphology, thickening, and calcifications.
- *CT*: (1) Coronal MIP reformatted image obtained during systole; (2) restriction of the aortic valve orifice; (3) thickening and calcification of the aortic valve cusps, calcification is associated with the severity of stenosis and it can be quantified; (4) decreased excursion of the valve cusps.
- *MR*: (1) direct jet visualization; (2) stenotic jet could be not parallel to the LV outflow tract; (3) late enhancement can be present in severe long-standing stenosis as patchy mid-wall enhancement, usually in conjunction with significant left ventricular hypertrophy.
- *Quantitative Flow Measurement*
  - For a flow quantification, in-plane velocity mapping in the outflow tract is used usually just distal to the valve tips; adapt velocity encoding to actual velocity using the lowest velocity without aliasing.
  - Through-plane velocity mapping in a plane perpendicular to the direction of flow, at the identified location of peak velocity.
  - For a flow quantification in-plane velocity mapping in the outflow tract, manually adjust the velocity window.

Table 3 Degree of aortic valve stenosis

Aortic valve stenosis			
Degree	Area (cm^2)	Mean gradient (mmHg)	Jet velocity (m/s)
Mild	1.5	<25	<3.0
Moderate	1.0–1.5	25–40	3.0–4.0
Severe	<1.0	>40	>4.0

Aortitis

- Broad category of infectious or noninfectious conditions in which there is abnormal inflammation of the aortic wall.
- Classification: (1) Noninfectious aortitis occurs in large-vessel vasculitis such as Takayasu arteritis and giant cell arteritis; aortic involvement is also seen in other rheumatic disorders such as rheumatoid arthritis, seronegative spondyloarthropathies, Reiter syndrome, Behcet disease, SLE, radiation-induced aortitis, and some idiopathic conditions; (2) infectious aortitis may be secondary to tuberculosis, syphilis, or infection with Salmonella or other bacterial or viral pathogens.
- *CT/MR*: Multimodality imaging approach is often required for the evaluation of both the aortic wall and aortic lumen, as well as for the surveillance of disease activity and treatment planning. PET imaging can be useful in the presence of equivocal findings.
- *Differential diagnosis*: Aortic intramural hematoma, aortic dissection.
- See also "Takayasu arteritis".

Apex, Ventricular

- Apical scar and akinesia after surgical intervention.
- Postsurgical apical false aneurysm.

- Thickness left ventricular apex in basal study: (1) apical thrombus post-myocardial infarction; (2) apical hypertrophic cardiomyopathy.
- *MR*: Perform EG and LE acquisitions to differentiate the two forms.

Arrhythmia

- *MR*: (1) Use fast sequence reducing number of acquisitions; (2) in patient with severe arrhythmia, a real-time acquisition can be used to evaluate ventricular volumes.
- *CT*: (1) Prospective gating technique allows to study patients with mild arrhythmia because data is rejected if the R-R interval exceeds a certain tolerance. In contrast the scan time is increased. Inject more medium contrast in arrhythmic patient when using prospecting gating.
- Antiarrhythmic medication administration is mandatory prior the exam.
- Arrhythmia can influence the accuracy of ventricular volumes.

Arrhythmogenic Right Ventricular Cardiomyopathy

- Genetic cardiomyopathy characterized by fibrofatty replacement of the right ventricular myocardium.
- In the early stage of pathology structural replacement may be absent or confined to a localized region of the RV, generally the inflow tract, outflow tract, and apex of the right ventricle (triangle of dysplasia).
- Patients could present symptomatic arrhythmias and right ventricle morphological abnormalities.
- Diffuse disease may result in biventricular heart failure, whereas ventricular arrhythmias may or may not be present.

- Fibrofatty infiltration: Specific histology findings of this pathology are fibrofatty replacement of myocardium of right ventricle in sub-tricuspid portion, outflow tract, and apex.
- *MR*: (1) Sensitivity and specificity of magnetic resonance to discover myocardial fibrofatty infiltration in ARVC between 22 and 100 %; (2) BB images are usually used for evaluation of fibrofatty infiltration; (3) signs of ARVC include focal hypokinesis, akinesis, and dyskinesis; (4) LE: useful for the evaluation of fibrofatty infiltration. It is frequently observed in anterobasal region and right ventricular outflow tract. LE usually seen only in advanced disease.
- Ventricular function: Majority of patients (75 %) compatible with diagnosis of ARVC present various degree of right ventricle enlargement and dysfunction.
- Diffuse LV involvement: consider alternative diagnosis (e.g., sarcoidosis).
- Pitfalls: dyskinetic area near moderator band could be normal.
- *Differential diagnosis*: dilated cardiomyopathies, sarcoidosis, valvular or congenital disease responsible for RV dilatation.
- The diagnosis is not made with CMR alone!
- ARVD Task Force Criteria: definite diagnosis, 2 major OR 1 major + 2 minor; borderline, 1 major + 1 minor OR 3 minor; possible, 1 major OR 2 minor.

Table 4 ARVD Task Force Criteria

2010 ARVD Task Force Criteria	
1. *Global/regional dysfunction/structural alterations*	
Major	Regional RV akinesia or dyskinesia or dyssynchronous RV contraction *and* one of the following: Ratio of RV EDV/BSA ≥110 mL/m^2 (male) or ≥100 mL/m^2 (female) or RV ejection fraction ≤40 %
Minor	Regional RV akinesia or dyskinesia or dyssynchronous RV contraction *and* one of the following: Ratio of RV EDV/BSA ≥100 to <110 mL/m^2 (male) or ≥90 to <100 mL/m^2 (female) or RV ejection fraction >40 to ≤45 %

Table 4 (continued)

2010 ARVD Task Force Criteria	
2. *Tissue characterization*	
Major	Residual myocytes <60 % by morphometric analysis (or <50 % if estimated), w/fibrosis replacement of the RV free wall in ≥1 sample, w/ or w/o fatty replacement of tissue on endomyocardial biopsy
Minor	Residual myocytes 60–75 % by morphometric analysis (or 50–60 % if estimated), w/fibrosis replacement of the RV free wall in ≥1 sample, w/ or w/o fatty replacement of tissue on endomyocardial biopsy
3. *Repolarization abnormalities*	
Major	TWI (V_1, V_2, V_3) or beyond; >14 years; in the absence of complete RBBB QRS ≥120 ms
Minor	TWI in V_1 and V_2 or beyond; >14 years; in the absence of complete RBBB or in V_4, V_5, or V_6 TWI in V_1–V_4; >14 years; in the presence of complete RBBB
4. *Depolarization/conduction abnormalities*	
Major	Epsilon wave in right precordial leads (V_1–V_3)
Minor	LP by SAECG in ≥1 of 3 parameters in the absence of QRS duration ≥110 ms on ECG Filtered QRS duration ≥114 ms Duration of terminal QRS < 40 μV (LAS duration) ≥38 ms RMS voltage of terminal 40 ms ≤20 μV TAD of QRS ≥55 ms measured from nadir of S wave to end of QRS in the absence of RBBB
5. *Arrhythmias*	
Major	NSVT or sustained VT
Minor	NSVT or sustained VT or RV outflow configuration, LBI axis or of unknown axis >500 ventricular extrasystoles per 24 h (Holter)
6. *Family history*	
Major	ARVC confirmed in FDR who meets TFC ARVC confirmed pathologically at autopsy or surgery in FDR Pathogenic mutation
Minor	History of ARVC in FDR in whom is not possible to determine if it meets TFC Premature SD (<35 years) due to suspected ARVC/D in FDR ARVC confirmed pathologically or by current TCF in second-degree relative

Artifacts, Magnetic Resonance

- To reduce artifacts due to metallic objects or device: (1) Put a saturation band on the ferromagnetic object which causes the artifact; (2) use the shimming; (3) gradient-echo sequences are more prone to artifacts, use spin echo; (4) in LE imaging use spoiled gradient-echo sequences which are less prone to susceptibility artifacts than balanced gradient-echo sequences with magnetization recovery.

Assiste Device, Left Ventricular

- Left ventricular assist device (LVAD) is an automatic pump which helps cardiac function in patient with severe heart failure waiting for transplantation (artificial heart).
- They are also used in patients with a potentially reversible cause of heart failure.
- CT can be performed with good results.
- MR cannot be performed.

Atrial Fibrillation

- Most common cardiac arrhythmia (0.5–1 %).
- Loss of atrial coordinated contraction with atrial dilatation.
- Irregular ventricular rate and absence of P waves.
- Ventricular rate depends on AV nodal function.
- Atrial trigger pints arise near the pulmonary vein (PV) orifice.
- Therapy: catheter ablation, two ways—(1) electrical isolation between LA and each PV (risk, 3 % pulmonary stenosis) and

(2) anatomical isolation which creates an ablation line isolating not only the PV but the LA adjacent tissue (no risk of pulmonary stenosis).
- *CT/MR*: (1) Angiographic evaluation of pulmonary veins (anomalous vessel); (2) images fusion with electrophysiology data to obtain morpho-functional map.
- New MR sequences can evaluate atrial fibrosis post-ablation therapy to assess complete/incomplete arrhythmogenic foci isolation.

Atrial Isomerism

- Right isomerism: two right-sided atria.
- Left isomerism: two left-sided atria.
- Usually associated with abdominal organ anomalies (e.g., azygos continuation).

Atrial Septal Aneurysm

- Intact atrial septum with significant movement of membranous septum at least 15 mm from diastole to systole.

Atrial Septal Defect

- Interatrial communication.
- Type: (1) Ostium secundum (fossa ovalis), most common; (2) ostium primum (anterior fossa ovalis) occurs at the atrioventricular level, often involves AV valves (mitral valve cleft), and might be associated to atrioventricular septal defect

(AVSD); (3) sinus venosus (adjacent to superior/inferior vena cava) can be associated with anomalous pulmonary vein drainage; (4) coronary sinus, the defect is in the wall of the coronary sinus.

- Increased pulmonary flow which can cause pulmonary hypertension. Only 10 % of ASD evolves into pulmonary angiopathy.
- Eisenmenger's syndrome in long-standing defects.
- Later ASD closure (after II decade of life) reverses remodeling of right ventricle.
- Restrictive ASD: usually small defect with pressure gradient between the atria. In case of restrictive ASD, there is an increase of RVSV and PA flow with no RV dilatation.
- Unrestrictive ASD: The defect is larger than mitral valve annulus. The amount of shunt in case of unrestrictive ASD is mainly related to the ventricular diastolic function.
- ASD should be closed if >1 cm^2 or 1/3 of the length of the septum.
- Qp/Qs >2 indicates a large shunt.
- *MR*: (1) Not recommended for the diagnosis of small ASD. (2) It is used to visualize dimensions and rims for larger ASD when TOE is contraindicated. (3) MR useful to assess ASD dimension, rim, and flow quantification especially if a percutaneous closure device is used. (4) Useful in post-treatment follow-up to assess device position and residual defects. *Tips and tricks*: (1) Reduce slice thickness on phase contrast (5–6 mm) for flow quantification when measuring ASD/VSD; (2) short axis evaluation on atrial chambers.
- Percutaneous closure device positioning: at least 0.5–1 cm rim surrounding the defect should be present.
- Reporting: (1) site, size, number of defects; (2) degree of shunt (Qp/Qs and phase contrast); (3) atrial dimension; (4) anomalous pulmonary vein drainage.
- See also "Qp/Qs" and "Ventricular septal defect".

Atrial Situs Inversus

- Right atrium in the left thorax and left atrium in the right.
- Normally associated with situs inversus.
- See also "Heterotaxic syndrome".

Atrioventricular Block

- Disease at atrioventricular node (nodal) or His–Purkinje system (infranodal).
- Causes: fibrosis, ischemia, hypertension, cardiomyopathies, myocarditis, infiltrative disease, cardiac surgery.
- First-degree block: PR interval >200 ms.
- Second-degree block: (1) Mobitz 1, PR interval prolong until a P wave is notconducted; (1) Mobitz 2, fixed P to QRS (2:1, 3:1 or 4:1).
- Third-degree block: no conduction, dissociation between P and QRS complex.

Atrium, Left

- Atrial dimensions should be indexed by BSA.
- Age and gender have no significant influence on atrial dimensions.

Table 5 Left atrium values

Left atrium values				
	Normal	Mild dilated	Moderately dilated	Severely dilated
Diameter (mm)	28–40	41–46	47–52	>52
Major Axis (mm)	41–61	62–67	68–76	>77
Area (cm^2)	<20	20–30	30–40	>40

Atypical Chest Pain

- Chest pain in the absence of typical characteristic of myocardial ischemia.
- *Differential diagnosis*: (1) acute coronary syndrome; (2) acute aortic syndrome (dissection, aneurysm rupture, intramural hematoma); (3) pulmonary embolism; (4) pneumothorax; (5) other thoracic diseases (esophageal rupture, tumors).
- *CT*: coronary CT for triple rule out (coronary, aorta, pulmonary arteries).
- *MR*: not used in routine practice.

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B

Balloon Atrial Septostomy

- Performed in newborns with transposition of the great arteries.

Balloon Valvuloplasty

- Contraindications: (1) thrombus in left atrial appendage; (2) moderate mitral regurgitation; (3) severe aortic or tricuspid valve disease.

Barlow's Syndrome

- Familial form of mitral valve prolapse.

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Bentall Operation

- Ascending aorta and aortic valve replacement with a valved conduit and reimplantation of the coronary arteries used to treat combined aortic valve and ascending aorta disease.

Bernoulli Formula

- Gradient (mmHg) = $4V^2$.
- Simplified Bernoulli formula to calculate the pressure gradient from peak velocity. *V*: peak velocity (m/s).

Beta-Blockers

- Beta receptor antagonist.
- Helpful in HR reduction.
- Optimal administration should start 2–3 days before examination.
- They are also effective if administered the same day (maximum HR reduction around 10 bpm).
- Contraindications: asthma, second- or third-degree hearth block, bradycardia.

Biological Risk

- The effect of ionizing radiation can be divided into two categories: (1) deterministic effects (skin erythema, skin necrosis, hair loss), seen immediately after radiation doses that lie well above those administered in cardiac CT, and (2)

stochastic effects, seen after a long latent period and associated with low exposures. Stochastic effects occur randomly, are mediated by chemical damage to the DNA molecules, and clinically manifest as genetic defects and an increased risk of cancer; the risk of their occurrence depends on the tissue, the age, and the sex of the subject receiving the radiation.

Blalock–Taussig Shunt

- Systemic to pulmonary arterial shunt using a subclavian arterial flap or Gore-Tex® to increase pulmonary blood flow in cyanotic congenital heart disease.

Body Mass Index

- BMI: weight/height^2 (kg/m^2).

Bourneville–Pringle Disease

- Genetic autosomal dominant disease with hamartomas of the heart and kidneys.

Breath Hold

- *MR*: maximum expiratory breath hold reduces diaphragm involuntary movements.
- If patient cannot afford a long breath hold, try to reduce sequence duration.

Brock Procedure

- Palliative procedure in ToF patients.
- Resection of RVOT musculature and valvulotomy of the pulmonary valve.

Brugada Syndrome

- Genetic autosomal dominant disease with variable penetrance.
- RBBB with ST elevation in V_1–V_3.
- Increased risk of sudden cardiac death in young adults.
- Differential diagnosis: ARVC.

Bundle Branch Block

- Disease in His–Purkinje system.
- QRS >120 ms.
- Causes: fibrosis, ischemia, hypertension, cardiomyopathies, myocarditis, infiltrative disease, cardiac surgery.
- Left bundle branch block (LBBB): large R waves in V_1 and V_6 and "M" pattern in V_1. Asynchronous contraction of the left and right ventricle with functional impairment.
- Right bundle branch block (RBBB): RSR pattern in V_1 and prominent S wave in I and V_6.
- Bifascicular block: RBBB + left anterior hemiblock (left axis deviation) and RBBB + left posterior hemiblock (right axis deviation).
- Trifascicular block: bifascicular block + first-degree AV block.

- Do not require temporary pacing unless transvenous pacing wire in case of hemodynamic impairment.

Bypass, Coronary

- Preoperative: evaluate the course and patency of arterial conduits in order to better plan the surgical approach.
- Postoperative: (1) Evaluate and monitor graft patency; (2) identify the possible progression of atherosclerotic disease in native vessels.
- Bypass patency: Within the first postoperative month, the primary mechanism for graft failure is thrombosis. Need to evaluate proximal anastomosis, graft body, and distal anastomosis. When present, graft stenosis or occlusion generally occurs at the distal anastomosis owing to the retrograde progression of coronary disease.
- Late LIMA graft failure more commonly occurs from progressive atherosclerotic disease of the grafted native vessel distal to the anastomosis.
- Types of bypass: (1) LIMA, used to revascularize the LAD artery; (2) RIMA, commonly implanted as a free graft (with proximal anastomosis on the ascending aorta and distal anastomosis on the target coronary) or composite graft, with proximal anastomosis on a LIMA graft and distal anastomosis on the left circumflex artery (LCX) territory, with a Y- or T-shaped configuration; (3) SVG, normally anastomosed proximally on the anterior wall of the ascending aorta (on the left side for grafts to the LAD territory or LCX, on the right side for those to the RCA territory) and distally below the stenosis or obstruction of the native coronary; (4) radial artery, used as a free or Y- or T-shaped composite graft, often as a third-choice conduit anastomosed distally on the LAD or LCX territory, after grafts with dominant LIMA–LAD and SV.

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C

Calcium Score

- Coronary artery calcium scoring using noncontrast CT is a clinically useful noninvasive estimate of coronary artery disease burden.
- Calcium score is a predictor of cardiovascular events.

Cardiac Index

- Cardiac output normalized for body surface (l/min/m^2).

Table 1 Calcium score and risk of cardiovascular events

Calcium score	Cardiovascular risk
0–100	Low
101–400	Intermediate
401–1,000	High
>1,000	Very high

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Cardiac Resynchronization Therapy

- Treatment for symptomatic heart failure (NYHA III–IV).
- Positioning of a biventricular pacemaker in order to reduce ventricular dyssynchrony due left bundle branch block.
- Pacing lateral LV wall (via coronary sinus) and septum (via RV).
- Improves cardiac output.
- *CT*: can be useful preimplantation to assess coronary sinus perviety.

Cardiomyopathies

- Previously classified as diseases of unknown cause with primary myocardial involvement.
- Actually reclassified according to predominant pathophysiological process since many genetic causes have been discovered.
- WHO classification: (1) dilated cardiomyopathy; (2) hypertrophic cardiomyopathy; (3) restrictive cardiomyopathy; (4) arrhythmogenic right ventricular cardiomyopathy.

Catheter Ablation

- Interventional technique aimed to destroy abnormal tissue. Used in atrial fibrillation to isolate arrhythmogenic trigger points.
- Energy sources: (1) radio frequency; (2) cooled radio frequency; (3) cryoablation.

Chagas Disease

- Myocarditis of parasitic origin caused by the Trypanosoma cruzi.
- Acute disease: most common in children; presentation, fatal myocarditis.
- Chronic disease: mostly asymptomatic; presentation, cardiomyopathy, megaesophagus, and megacolon.

Chiari Network

- Highly mobile network of weblike strand attached to the tip of Eustachian valve or right atrium wall.
- *Differential diagnosis*: vegetation or mass.

Chronic Coronary Occlusion

- Completely occluded coronary artery for >3 months.
- Age and length of occlusion are major determinants of PCI success.

Churg–Strauss Syndrome

- Rare small-vessel vasculitis.
- *MR*: (1) high-intensity signal in STIR sequences in acute stage; (2) LE involves subendocardial segments, unlike other myocarditis.
- See also section "Myocarditis, Eosinophilic".

Cine Sequence, High Temporal Resolution

- Useful to assess SAM in HCM patient in 3-chamber view.
- To create high temporal resolution sequence: reduce the number of acquired segments and increase the number of acquired phase.

Claustrophobia

- 20 % of the general population.
- Patient positioning important: try prone position or head outside.
- Mild sedation (e.g., benzodiazepine).

Common Atrioventricular Canal

- Also known as complete atrioventricular septal defect (AVSD).
- Often associated with Down syndrome and other congenital abnormalities.
- Surgical correction with common AV valve repair (cleft closure and valvuloplasty) and patch closure of septal defect.
- After complete correction look for residual left AV valve insufficiency.

Congenitally Corrected Transposition of the Great Arteries

- Congenital anomaly with atrioventricular and ventriculoarterial discordance.
- The right ventricle supports the systemic circulation and the left ventricle the pulmonary circulation.

- Rare disease with normal survival rate.
- Major long-term problem is atrioventricular valve regurgitation associated with systemic right ventricular failure.

Constrictive Pericarditis

- Causes: tuberculosis, mediastinal irradiation, surgery, trauma, and purulent pericarditis.
- *Characteristics*: (1) small-volume pulse; (2) pulsus paradoxus; (3) atrial fibrillation; (4) pleural effusion; (5) cardiac catheterization—elevation and equalization of filling pressure (RV and LV pressure difference ≤6 mmHg).
- *CT*: (1) pericardial thickness (>3 mm); (2) pericardial calcification.
- *MR*: (1) pericardial thickness; (2) inspiratory septal bowing during early diastole.
- See also section "Interventricular septum movement".

Contrast-to-Noise Ratio

- Relative signal-to-noise differences from two different regions.
- CNR: $(S_1 - S_2)/\sigma$.
- S_1 and S_2: mean signal intensity from the two regions; σ, standard deviation of the background noise.

Conversion Factors, Radiation Dose

- Estimate of effective dose from the DLP.
- E_{eff}: conversion factor • DLP.

Table 2 Conversion factors according to European Commission Guidelines 2000

Region of body	Conversion factor (mSv/mGy · cm)
Head	0.0023
Neck	0.0054
Chest	0.017
Abdomen	0.015
Pelvis	0.019

Cor Triatriatum

- Thin membrane that divides right (cor triatriatum dextrum) or left atrium (sinistrum).
- Rare (0.1 % of all cardiac malformations) and frequently associated with other congenital abnormalities.

Coronary Artery, Anomalous Origin

- Incidence: 1–2 % of cases.
- Malignant: when the vessel courses between the ascending aorta and the pulmonary artery, leading to compression in systole during exercise (risk of sudden cardiac death).
- Benign: other anomalies with no interarterial course.
- High takeoff when the coronary ostium is across/above the sinotubular junction.
- Anomalous origin of LCA from pulmonary artery (ALCAPA) and anomalous origin of RCA from pulmonary artery (ARCAPA) are extremely rare, usually symptomatic in infant but sometimes asymptomatic and discovered in adult age.
- Intervention: (1) coronary reimplantation; (2) stenting.
- *CT*: accurate depiction of coronary anomalies.
- *MR*: visualization of coronary origin and proximal course. Long acquisition time.

Crisscross Anatomy

- Also known as twisted atrioventricular connection.
- Rare congenital cardiac anomaly characterized by crossing of the inflow streams of the two ventricles due to an apparent twisting of the heart about its long axis.
- In most cases there is hypoplasia of the tricuspid valve and right ventricle, a ventricular septal defect, abnormal ventriculoarterial alignments, and pulmonary stenosis.
- The mitral valve and tricuspid valve are not in the same plane; the mitral valve opens from right atrium to left ventricle, whereas the tricuspid valve opens from left atrium to right ventricle.
- Patients are typically neonates with cyanosis and a systolic murmur.
- *MR*: difficulty to obtain four-chamber view.

Crista Terminalis

- Ridge of tissue between SVC and right atrial appendage.
- *Differential diagnosis*: vegetation or mass.

CT Dose Index

- In computed tomography, direct measurement of absorbed dose is delivered through an index called CTDI that from mathematical point of view is the integral of the single-scan radiation dose profile along the z-axis, normalized to the thickness of the imaged section.

$CTDI_W$

- $CTDI_W$: weighted average of CTDI as the sum of the measurements made at the center ($CTDI_c$) and periphery ($CTDI_p$) of the phantom, 1 cm below the surface, according to the following mathematical equation: $CTDI_W = 1/3\ CTDI_c + 2/3\ CTDI_p$.
- $CTDI_w$ is clearly defined according to a single axial scan and does not include any correction for the pitch value used in the spiral scan.

CTDI Volume

- $CTDI_{vol}$: $CTDI_w$ divided by pitch.
- This index takes into account the average radiation exposure over *x*, *y*, and *z* directions.
- The most available dose index, directly viewable on the monitor of all the modern equipment during a CT examination and provides an immediate check of the dose delivered to the patient.

Culprit Plaque

- Acute coronary events, such as unstable angina, myocardial infarction, or sudden cardiac death, are usually caused by erosion or rupture of a coronary atherosclerotic plaque.
- In the majority of cases, the "culprit lesion" does not reduce the lumen of the coronary artery to a significant extent before the acute coronary event.

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D

Damus–Kaye–Stansel Operation

- Surgical operation performed in TGA, single ventricle, and restrictive VSD causing subaortic stenosis.
- Side-to-side aorta and pulmonary artery connection to provide unrestricted blood flow from the systemic ventricle to the aorta.

D-Dimers

- High negative predictive value for PE and DVT.
- Positive D-dimer results with medium–high clinical probability of PE should be followed by CTA.

Dextrocardia

- Anomalous cardiac position with the apex pointing the right chest wall.
- Cardiac anatomy may be normal.

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- Check for other congenital cardiac lesions.
- *Differential diagnosis*: in case of abnormal heart position, look for congenital absence of pericardium.

Diastolic Dysfunction

- See section "Heart failure".

Diastolic Tail

- See section "Aortic coarctation".

DiGeorge Syndrome

- Genetic disease on chromosome 22 leading to thymic hypoplasia with low T cell count, hypoparathyroidism with hypocalcemia, and outflow tract defects of the heart (ToF, truncus arteriosus, interrupted aortic arch, right-sided aortic arch, aberrant right subclavian artery).

Dilated Cardiomyopathy

- Impaired systolic function with dilatation of cardiac chambers.
- Diastolic function can be normal or impaired.
- Causes: inherited (25 %), myocarditis, metabolic, nutritional, and persistent tachycardia. Usually diagnosis of exclusion.

- *Differential diagnosis*: ischemic heart disease, valvular disease, adult congenital heart disease, left ventricular noncompaction, iron-overloaded cardiomyopathy, alcoholic cardiomyopathy, hypertensive heart disease.
- See also section "Cardiomyopathies".

Dipyridamole

- Indirect vasodilator agent used in stress MR.
- Increase endogenous levels of adenosine blocking cellular uptake.
- Dipyridamole dose: 0.56 mg/kg IV over 4 min.
- Prolonged action (~30 min).
- Low-dose protocol: infusion of a total dose of 0.56 mg/kg dipyridamole in 4 min, with imaging started immediately after completion of the 4 min infusion.
- High-dose protocol: adds a second injection of 0.28 mg/kg dipyridamole for 2-min duration, with imaging initiated at 8 min after the beginning of the first injection (a total dose of 0.84 mg/kg dipyridamole is injected in the high-dose dipyridamole infusion protocol).
- Patients should avoid methylxanthine-containing products for 24 h prior the scan.
- Contraindications: (1) high-grade AV block; (2) asthma or COPD; (3) sinus bradycardia; (4) systemic hypotension (BP <90 mmHg); (5) severe carotid stenosis.
- Side effects: transient heart block, transient hypotension, transient tachycardia, bronchospasm.
- Antagonist: aminophylline, 50–100 mg over 1 min, injection can be repeated up to 250 mg total dose.
- See also section "Perfusion imaging, myocardial".

Dobutamine

- Positive inotropic agent used in stress MR.
- Increases heart rate and myocardial contractility.
- High-dose protocol: IV dobutamine infusion at 3 min stages (10, 20, 30, 40 μg/kg/min).
- Target heart rate: (220 age) × 0.85. If not reached at 40 μg/kg/min, atropine in 0.25 mg fraction (2 mg max.) if heart rate response is poor.
- Low-dose protocol: 5–10 μg/kg/min.
- Contraindications: (1) severe hypertension (>220/120 mmHg); (2) congestive heart failure; (3) unstable angina (4) aortic valve stenosis (peak gradient >50 mmHg); (5) HCM; (6) complex arrhythmias; (7) myocarditis; (8) pericarditis.
- See also section "Perfusion imaging, myocardial".

Dominance, Coronary

- Coronary artery dominance refers to which artery supplies the posterior part of the heart.
- In 85–90 % is the right coronary artery (right dominance).
- In 8–10 % is the circumflex artery (left dominance).
- In 5 % the inferior wall is vascularized both from RCA and Cx (codominant or balanced circulation).

Dose Length Product

- DLP: $CTDI_{vol}$ × scan length.
- It is an indicator of total exposure for a complete CT scan, which allows us to compare the dose with several adjustments of technical parameters in order to optimize patient protection.

Double Outlet Right Ventricle

- >50 % of great vessels arise from the right ventricle.
- Large subaortic VSD.
- Wide abnormalities spectrum: from Fallot type to transposition of the great arteries.
- Can be associated with RVTO stenosis.
- *MR*: (1) vascular connection, (2) ventricular volumes and function, (3) RVTO stenosis, (4) shunts.

Dressler Syndrome

- A myocardial infarction-associated pericarditis with delayed onset typically 1 week after infarction to several months.
- Suspected autoimmune etiology.

Ductus Arteriosus or Ductus Botalli

- A fetal blood vessel connecting the pulmonary artery to the aortic arch.
- Fibrosis and closure at birth (ligamentum arteriosum).

Ductus Arteriosus, Persistent

- Left-to-right extracardiac shunt caused by patent ductus arteriosus.
- *MR*: (1) shunt detection; (2) quantification of shunt degree.

Dyslipidemia

- Primary hyperlipidemias: (1) familial hyperchylomicronemia; (2) familial hypercholesterolemia; (3) familial defective apoprotein B-100; (4) polygenic hypercholesterolemia; (5) familial combined hyperlipidemia; (6) dysbetalipoproteinemia; (7) familial hypertriglyceridemia; (8) type V hyperlipoproteinemia.
- Secondary hyperlipidemias: (1) renal failure; (2) nephrotic syndrome; (3) hypothyroidism; (4) type II diabetes and obesity; (5) alcohol abuse; (6) cholestasis; (7) drugs.
- Normal range for plasma lipid levels: (1) total cholesterol, 150–250 mg/dL; (2) LDL cholesterol, <160 mg/dL; (3) HDL cholesterol, 30–75 mg/dL; (4) triglycerides, 70–175 mg/dL.

Dyssynchrony, Cardiac

- Three types: (1) atrioventricular (PR > 120 ms); (2) interventricular (delay between RV and LV contraction); (3) intraventricular (differences in regional wall motion).

Dystrophies, Muscular

- Hereditary muscle disease causing progressive severe skeletal muscle weakness, which can lead to dilated cardiomyopathy.
- Most common: Duchenne, Becker, limb girdle muscular dystrophies.
- *MR*: (1) left ventricle dysfunction; (2) myocardial edema and inflammation; (3) late enhancement similar to myocarditis.

Suggested Reading

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E

Early Gadolinium Enhancement

- Useful to assess cardiac thrombus and no-reflow phenomenon.
- 2–5 min after contrast medium administration.
- Inversion time: 460 ms.
- Cardiac planes: 4CH, 2CH, LVOT ± SA.

Ebstein's Anomaly

- *Characteristics*: congenital malformation with dysplasia of the tricuspid valve and abnormal attachment of the tricuspid leaflets (septal and inferior) leading to an apical displacement of the valve, resulting in atrialization of the right ventricle and a small RV chamber with significant tricuspid regurgitation.
- Associated with pulmonary stenosis/atresia, VSD, and ASD.

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- Ebstein's anomaly when the AV valve offset is >8 mm/m^2 or >15 mm; otherwise talk about dysplastic tricuspid valve.
- *MR*: (1) Measure offset between AV valves plane in the 4-chamber view; (2) degree of RV atrialization; (3) RV volumes and function; (4) severity of tricuspid regurgitation.

ECG

- ECG interpretation during MR examination is limited due to the magnetohydrodynamic effects.
- ECG aspects that can be evaluated: heart rate, extrasystoles, and atrial fibrillation.

ECG, Exercise

- Provocative test to detect significant coronary disease.
- Coronary artery disease sensitivity 68 %, specificity 77 %.
- Indications: diagnosis of IHD, post-MI, pre- and post-revascularization, arrhythmia evaluation.
- Causes of false-positive test: cardiomyopathies, hypertension, mitral valve prolapse, LVOT obstruction, resting ECG abnormalities.

ECG, Leads

- White: right arm (RA).
- Green: right leg (RL).
- Black: left arm (LA)—in case of 3-lead system, it is absent.
- Red: left leg (LL).

ECG, Preparation

- Accurately remove excessive hair and use abrasive skin preparation.
- ECG signal can be significantly increased.
- In case of unsuccessful triggering, use finger pulse signal.

ECG Pulsing

- A modulation system of ECG-controlled tube current output during retrospectively gated acquisitions. The system is based on the essential requirement that the best phase of the cardiac cycle in which to reconstruct the images is the mesodiastolic phase, the phase of greater immobility of the heart and coronary arteries; thus, while X-ray is turned on, tube current is raised to a maximum level in the mesodiastolic phase (100 % dose) where you need maximum signal-to-noise ratio and reduced gradually to a minimum (decreased up to 80 %) in the systolic phase, leading up to 50 % reduction of delivered radiation dose.
- The optimal "pulsing window" (when current output becomes maximal) has to be as short as possible, typically focused around mid-diastole. This becomes a complex decision according to pulse window width, heart rate, and scanner type.
- General rule: HR <65 beats/min, best phase at mid-diastole (65–75 % of the RR interval); HR > 70 beats/min, best phase may vary from 30 to 80 %.

Edema, Myocardial

- Causes: acute myocardial infarction, myocarditis, cardiomyopathies, infiltrative disease, tumor.
- *MR*: (1) can assess myocardial edema using T_2-weighted images with fat suppression (STIR); (2) to be sure of myocardial edema

in anterior septal wall, switch off cardiac phased-array coil, and if myocardial hyperintensity persists, it is true edema; (3) diffuse edema can be difficult to recognize, use myocardial SI/skeletal muscle SI, and a ratio ≥2 is abnormal.

Effective Dose

- The sum of any weighted equivalent dose from each organ or tissue can be calculated as follows: $E = \sum_{T,R} W_T \cdot W_R \cdot D_T$, where D_T is the absorbed dose (mGy) in tissue T due to radiation R, W_R is the weighting factor for radiation R, and W_T is the weighting factor for tissue T that takes into account the radiosensitivity of individual organs.

Table 1 Typical effective dose values for CCTA and non-CT imaging examinations

Imaging examination	Effective dose (mSv)
Background radiation	2–4
Non-CT examinations	
Chest X-ray	0.02
Coronary angiography (diagnostic)	7
Dual isotope TI/Tc-99	22
Rest–stress Tc-99	11
Thallium rest distribution	11
Low-dose Tc-99 stress only	3
FDG-PET	5
CCTA examinations	
Retrospective gating	12–20
Prospective gating	4–7
Abdominal CT	5–7
Prospective gating + iterative reconstruction	3–5
High-pitch modality	8–12
High-pitch modality	<1
Calcium score	1–3

Ehlers–Danlos Syndrome

- Inherited defect in synthesis and metabolism of different type of collagen producing connective tissue defects.
- Incidence: 1/400,000.
- *Characteristics*: joint hypermobility, skin hyperextensibility, mitral valve prolapse and regurgitation, aortic root ectasia.

Eisenmenger's Syndrome

- Any systemic-to-pulmonary circulation shunt causing progressive pulmonary hypertension which exceed systemic pressure leading to reversal or bidirectional flow of the shunt.
- Mainly caused by ASD, VSD, and AVSD.

Ejection Fraction

- EF: SV/EDV.
- EF can be reduced also in the presence of ectopic beats.

Embolic Protection Device

- Devices used in coronary angioplasty to prevent distal embolization.
- 2 types: balloon occlusion device and filter device.

Endocarditis, Infective

- Inflammation of the inner tissue of the heart and valves caused by infectious agents.
- Common organisms: 60 % Streptococci (viridians group), 10 % Enterococci, 25 % Staphylococci, 5–10 % culture negative.

- Complications: valve destruction, intracardiac abscess, AV block, septic emboli (20–45 % of patients).
- Right-sided endocarditis in drug users (pulmonary septic emboli).
- Diagnosis with Duke criteria.
- *TTE and TOE*: More sensitive imaging technique to demonstrate vegetations >2 mm (TOE >> TTE).
- *MR/CT*: Useful in the investigation of paravalvular extension and aortic root aneurysm.

Table 2 Duke criteria for infective endocarditis diagnosis

Duke criteria
Major criteria
1. Positive blood culture Typical microorganism for infective endocarditis from two separate blood cultures Persistently positive blood culture Single positive blood culture for Coxiella burnetii or phase I antibody Titer to C. burnetii > 1:800
2. Evidence of endocardial involvement Positive echocardiogram (vegetation, abscess, new partial dehiscence of prosthetic valve, new valve regurgitation)
Minor criteria
1. Predisposing conditions or drug use
2. Fever > 38°
3. Vascular phenomena Arterial emboli, septic pulmonary infarcts, mycotic aneurysm, intracranial or conjunctival hemorrhage, Janeway lesions
4. Immunologic phenomena Glomerulonephritis, Osler's nodules, Roth spot, rheumatoid factor
5. Microbiological evidence
6. Echocardiogram Positive for infectious endocarditis but not meeting major criteria

Definite endocarditis: 2 major criteria, or 1 major and 3 minor criteria, or 5 minor criteria. Possible endocarditis: findings do not fulfill criteria but are not rejected. Rejected diagnosis: alternative diagnosis or resolution of clinical features with <4 days of antibiotic therapy

Endocarditis, Prosthetic Valve

- Early: <2 months postoperatively (causes: Staphylococci, gram-negative bacilli, fungi, or diphtheroids).
- Late: >2 months postoperatively (causes: *Staphylococcus aureus*, *Streptococcus viridans*, or Enterococci).
- Complications: valve dehiscence, abscess, and hemodynamic failure (mortality 45–75 %).

Endomyocardial Fibrosis

- Restrictive obliterative cardiomyopathy which occurs in tropical regions.
- Endomyocardial fibrosis and Loeffler endocarditis could be a different spectrum of the same disease caused by hypereosinophilia.
- Disease causes severe fibrotic tissue apposition in the endomyocardial layer.
- Papillary muscles can be involved secondary to chordae tendineae adherence.
- May involve both ventricles.
- See also sections "Myocarditis, Eosinophilic" and "Restrictive cardiomyopathy".

Endovascular Aortic Aneurysm Repair

- The aim of endovascular procedure is to prevent aneurysm expansion and rupture.
- This procedure involves placing a covered stent (stent graft) in the aorta to serve as a blood flow conduit through the aneurysm sac. The stent graft is anchored to the proximal and distal ends of the non-aneurysmal segments of the artery.

Equivalent Dose

- A theoretical quantity for evaluating the probability of stochastic effects induced by given absorbed dose, which depend from the type and energy of the radiation dose delivered to organ and tissue irradiated.
- This quantity is defined as the absorbed dose normalized to a dimensionless radiation weighting factor for radiation R (W_R is typically 1 for X-rays). Thus, equivalent dose is a different entity from absorbed dose because it represents not only the amount of radiation delivered to tissues but also the biological damage.
- Its unit is the sievert (Sv), the resultant of the product of joule per kilogram.

Eustachian Valve

- A vestigial remnant of tissue attached to the inferior right atrium wall just above the inferior vena cava.
- Differential diagnosis: vegetation or mass.

Extramedullary Hematopoiesis

- Bilateral paravertebral masses or expansion of thoracic ribs.
- *Causes*: chronic hemolytic anemia, sickle cell disease, thalassemia major.
- *RM*: (1) isointense epidural lesion on T_1 and intermediate to high signal intensity on T_2; (2) vertebral body low signal on T_1 due to fatty marrow displacement by hematopoietic marrow; (3) post-contrast lesion enhancement.

Suggested Reading

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Kiefer TL et al (2012) Infective endocarditis: a comprehensive overview. Rev Cardiovasc Med 13:e105–e120

Warnes CA et al (2008) ACC/AHA 2008 guidelines for the management of adults with congenital heart disease. Circulation 118:e714–e833

F

Fetal Circulation

- It is supported by intra- and extracardiac shunts: ductus venosus (ductus of Aranzio), foramen ovale, ductus arteriosus.
- Umbilical vein, usually single, providing oxygenated blood from the placenta to the heart of the fetus.
- Umbilical arteries, usually two in number, originating from external iliac arteries.

Fibroelastoma, Papillary

- Benign cardiac tumor attached to valve apparatus.
- Rarely seen on MR due to the small size.
- *Differential diagnosis*: vegetation or myxoma.

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Fibroma

- Benign ventricular cardiac tumor usually intramural.
- Can cause mass effect.
- *MR*: ipo- to isointense on T_2 images.

Flail Leaflet

- Usually results from a ruptured chordae or papillary muscle.
- Severe regurgitation.

Flip Angle

- Reduce FA to reduce SAR (i.e., children or pregnancy).
- Attention: with SAR reduction also SNR is decreased.

Flow

- General equation: $\Delta\Phi = \gamma \cdot \Delta m \cdot v$.
- $\Delta\Phi$, phase difference; γ, gyromagnetic ratio; Δm, product of gradient area and time; v, velocity.
- $\sigma \sim$ velocity encoding/SNR.
- Time resolution $= 2 \cdot TR \cdot VPS$.
- *Tips and tricks*:
  - To increase SNR: increase thickness, flip angle, echo time, receiver bandwidth.
  - When a low temporal resolution is used, the peak velocity and flow in the great arteries are underestimated.

- Decreasing spatial resolution means underestimation of flow and peak velocity.
- Phase contrast images are optimized for laminar flow. Accelerated flow (turbulence or stenotic jet) causes lesser accuracy: use a short TE.
- Reducing TE and TR: increases temporal resolution (less sensible to motion artifacts), reduces SNR, increases scan time.
- Aliasing at the edge of vessel is usually due to shear stress or wall movement. Try to keep it out of the ROI; it may affect your peak velocity.
- Try to set the VENC as close as possible to the real peak velocity to reduce flow underestimation.
- Always do flow at isocenter to reduce inhomogeneities and to obtain more accurate data.
- In congenital heart disease use free-breathing averaged flow (usually 2 min of scanning) to get more information about flow volume and to be more precise on quantifying shunt (Qp/Qs).
- In order to get the true peak velocity, perform in plane flow first to visualize the highest velocity jet direction, then set the through plane flow perpendicular.
- To calculate peak velocity do not rely on data from a single voxel if it is significantly different from adjacent voxel; it can be inaccurate due to turbulence.
- Set the aortic and pulmonary flows above the valves to reduce turbulence, mimicking reverse flow.
- In case of aortic regurgitation, it may be useful to perform a subvalvular flow to quantify the exact amount of back flow.

Fontan Intervention

- Last stage of surgical palliation in complex intracardiac congenital anomalies (e.g., mitral or tricuspid atresia) resulting in functional single ventricle circulation.
- Fontan completion or total cavopulmonary connection (TCPC) is usually made with an extracardiac conduit between inferior vena cava and pulmonary arteries (right pulmonary artery or confluence), bypassing the right ventricle
- Oxygen desaturation is present with venovenous collaterals between systemic and pulmonary veins (i.e., ectatic vein between innominate vein and pulmonary veins).
- Increase of central venous pressure and/or of transpulmonary gradient is responsible for Fontan failure.
- Fontan failure simulates right heart insufficiency with abdominal/hepatic congestion and upper limb/head stasis.
- Extracardiac complication of Fontan circulation is hepatic fibrosis/cirrhosis, plastic bronchitis, and protein-losing enteropathy. Always look for focal hepatic lesions.
- *MR*: (1) pulmonary artery stenosis, (2) atrial enlargement, (3) atrioventricular valve/s regurgitation, (4) single ventricle function, and (5) conduit obstruction.
- *MR tips and tricks*: (1) To better visualize the conduit, perform 3D SSFP navigator and multiphase CE-MRI. (2) High-resolution time-resolved MRI is useful to better understand the flow direction, particularly in the presence of collateral flow.
- *CT*: (1) Should be performed in the presence of stenting or devices to increase spatial resolution; (2) contrast injection should be performed if possible using a double venous access and simultaneous contrast injection from upper and lower limbs (iodine contrast agent 370–400 mg/mol, 2–3 ml pro-Kg at flow rate of 2–2.5 mL/s). Acquisition delay between 55 and 65 s (equilibrium contrast) to better visualize systemic venous return and branch pulmonary arteries reducing contrast mixing artifacts.

Foramen Ovale, Patent

- Right-to-left shunt due to its flap-like nature.
- Mostly asymptomatic.
- Also with normal Qp/Qs a patent foramen ovale can cause trouble with paradoxical embolus or migraine.
- MR can miss small defect.
- Contrast echocardiography is the first diagnostic choice.

Fraction Flow Reserve

- FFR is defined as maximum myocardial blood flow in the presence of a stenosis divided by theoretical maximum flow in the absence of a stenosis.
- FFR correlates distal coronary pressure to myocardial blood flow during maximum hyperemia.
- FFR is useful to determine the contribution of a stenosis in causing myocardial ischemia and, thus, can be used to guide decision regarding coronary revascularization.

Friedreich's Ataxia

- Spinocerebellar degenerative disease characterized by ataxia.
- Cardiac involvement with concentric or septal left ventricular hypertrophy.
- More rare dilated cardiomyopathy.

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Warnes CA et al (2008) ACC/AHA 2008 guidelines for the management of adults with congenital heart disease. Circulation 118:e714–e833

G

Gadolinium

- Most common adverse effects (~1 %): nausea and vomiting, headaches, and urticaria.
- Risk of severe anaphylactic reaction: ~1 in 100,000–500,000.
- Should be avoided in patient with renal impairment (GFR <30 mL/min) for the risk of systemic nephrogenic sclerosis.
- No reported harmful effects in fetus during pregnancy or in newborn during breastfeeding.
- See also section "Nephrogenic Systemic Fibrosis".

Giant Cell Arteritis

- Aortic involvement occurs in 15 % of GCA patients.
- It usually manifests as annuloaortic ectasia or as an ascending aortic aneurysm that can extend into the aortic arch. Other possible manifestations are acute dissection, aortic valve insufficiency, or abdominal aortic aneurysm. Thoracic aortic aneurysms are usually a late complication of the disease.

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- *CT*: (1) aortic wall enhancement (early stage); (2) useful to describe luminal changes (stenosis, occlusion, dilatation, aneurysmal formation), calcification (chronic stage), and mural thrombi.
- *MR*: (1) same capabilities of CT imaging; (2) demonstration of mural and perivascular edema (which reflects disease activity).
- *FDG-PET*: reveals abnormal uptake in the affected extracranial segments in more than one-half of affected patients.

Glenn Shunt

- Also known as bidirectional cavopulmonary connection, it connects SVC to RPA.
- Second stage of surgical palliation in complex intracardiac congenital anomalies with functional single ventricle circulation.
- In case of restrictive/dysfunctioning RV is supporting pulmonary circulation by directing flow directly into RPA.
- Always look for pulmonary artery stenosis and SVC obstruction.
- In case of increased pulmonary pressure, there might be venovenous collateral (e.g., emiazygos, mammary vein, pericardial vein) redirecting flow to IVC territories, thus desaturating systemic blood.
- See also section "Fontan intervention".

Gray

- Dosimetric quantity representing the amount of energy absorbed per unit mass.
- One gray is the absorption of one joule of energy, in the form of ionizing radiation, per kilogram of matter.

Suggested Reading

Holloway BJ et al (2011) Imaging of thoracic aortic disease. Br J Radiol 84:S338–S354

Warnes CA et al (2008) ACC/AHA 2008 guidelines for the management of adults with congenital heart disease. Circulation 118:e714–e833

H

Heart Failure

- Clinical syndrome characterized by dyspnea and/or fatigue on exertion or at rest with evidence of fluid retention in the context of a structural or functional cardiac disorder.
- Clinical diagnosis can be made with Framingham criteria.

Table 1 NYHA criteria

NYHA functional class	
Class I	No limitation during ordinary activity
Class II	Slight limitation by shortness of breath and/or fatigue during moderate exertion or stress
Class III	Symptoms with minimal exertion that interfere with normal daily activity
Class IV	Inability to carry out any physical activity

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Table 2 Framingham criteria for the diagnosis of heart failure

Framingham criteria	
Major criteria	
1. Paroxysmal nocturnal dyspnea	5. S3 gallop rhythm
2. Raised JVP; distended neck veins	6. Hepatojugular reflux
3. Crepitations in lung fields	7. Weight loss >4.5 kg in 5 days in response to treatment
4. Acute pulmonary edema	
Minor criteria	
1. Bilateral ankle edema	5. Pleural effusion
2. Nocturnal cough	6. Tachycardia rate >120/min
3. Dyspnea on ordinary exertion	7. Decrease in vital capacity by one-third
4. Hepatomegaly	

Heart Failure, Diastolic

- Symptoms and signs of heart failure with preserved systolic function.
- Impaired ability of the left ventricle to fill in diastole.
- Causes: ischemia, restrictive or infiltrative cardiomyopathy, hypertrophy.
- Imaging technique to evaluate diastolic function: echocardiography with tissue Doppler or calculating *E*/*A* ratio.
- *E*/*A* ratio: pulsed Doppler at mitral inflow measures *E* wave (peak early diastolic velocity) and *A* wave (peak atrial systolic velocity).
- MR could indirectly assess diastolic dysfunction analyzing *E*/*A* ratio with through-plane phase contrast of mitral valve.

Table 3 Diastolic dysfunction classification

	Mitral inflow	Mitral inflow at Valsalva peak	LV compliance	Atrial pressure
Normal diastolic function	$0.75 < E/A < 1.5$	$\Delta E/A < 0.5$	Normal	Normal
Impaired relaxation	$E/A \leq 0.75$	$\Delta E/A < 0.5$	Normal or ↓	Normal
Pseudonormal	$0.75 < E/A < 1.5$	$\Delta E/A > 0.5$	↓↓	↑
Reversible restrictive	$E/A > 1.5$	$\Delta E/A > 0.5$	↓↓↓	↑↑
Fixed restrictive	$E/A > 1.5$	$\Delta E/A < 0.5$	↓↓↓↓	↑↑↑

Hemochromatosis

- See section "Iron overload, myocardial".

Heterotaxic Syndrome

- Defects in lateralization of paired organs resulting in incomplete or inappropriate development.
- Also known as "situs ambiguus," condition in between normal "situs solitus" and "situs inversus."
- Atrial situs defined by the morphology of appendages.
- Right atrial appendage is large, broad based, and triangular.
- Left atrial appendage is longer, narrow, and sometimes folded.
- Usually atrial situs matches the bronchial one; always look at airways and their relationships with pulmonary arteries.
- Right isomerism is usually associated with asplenia, intracardiac anomalies (on the side of pulmonary valve), and anomalous pulmonary venous return.
- Left isomerism is usually associated with polisplenia (multiple splenunculi) and intracardiac defect and electrical defect.

- Always look at the abdominal situs (solitus or ambiguus transverse or left-sided liver) and look for gut malrotation (clockwise rotation of mesenteric vessels).
- Most of those conditions are partially corrected during infancy and palliated with univentricular circulation (Fontan).

Heyde's Syndrome

- Association between calcific aortic stenosis and gastrointestinal bleeding.
- Acquired von Willebrand's disease caused by high shear stress around the aortic valve.

Hibernating Myocardium

- State of persistently impaired myocardial function due to chronically reduced coronary blood flow.
- It can be restored to normal by improving blood flow (after surgical/percutaneous revascularization).

Holt–Oram Syndrome

- Genetic autosomal dominant disease with upper limb dysplasia and commonly AVD but also VSD and PDA.

Hurler Disease

- Inherited metabolic disorder associated with myocardial disease.

Hydatid Disease

- Cardiac involvement is unusual.
- Can cause obstruction, anaphylaxis, cystic/thrombotic material embolization, cardiac rupture.
- Surgical removal is required.

Hypertrophic Cardiomyopathy

- Hypertrophic cardiomyopathy (HCM) is a common cardiomyopathy (1:500) caused by mutations in genes encoding proteins of cardiac sarcomere.
- HCM is characterized by left ventricle hypertrophy in the absence of secondary pathology that can explain it.
- *MR*: (1) increased wall thickness: In adults, left wall maximum thickness ≥15 mm; in children, ≥2 SD above of mean wall thickness index to BSA, age, and sex; thickness between 13 and 15 mm, we have to distinguish HCM from hypertensive heart disease and athlete's heart; thickness equal or superior to 30 mm could be an indication for implantation of ICD. (2) asymmetric hypertrophy: usually anteroseptal mid-basal, less frequently apical; calculate diastolic wall thickness ratio (thickest/thinnest wall thickness in the same slice), ratio >2.0 may be considered abnormal. (3) LVOT or mid-cavity obstruction: LVOT is caused by anterior mitral leaflet–septal contact; LVOT obstruction usually is dynamic and changes with hemodynamic conditions of patient. If possible evaluate LVOT at rest and during Valsalva maneuver. Mid-cavitary obstruction can be present and it is caused by hypertrophic papillary muscles. Gradients ≥50 mmHg are an indication for surgical or percutaneous intervention if patient is symptomatic and does not benefit from medical therapy; PC sequences are useful in

Table 4 Dynamic left outflow tract obstruction diagnosis

	Basal obstruction (mmHg)	Labile obstruction (mmHg)	Nonobstructive (mmHg)
Rest	≥30	<30	<30
Physiologically provoked stress	≥30	≥30	<30

the evaluation of peak velocity. (4) LE: negative prognostic marker in patients with HCM; it is associated with a major risk to develop sudden cardiac death, ventricular arrhythmia, and heart failure; common distribution in ventricular septum and anterior wall rarely is situated in the free wall.

- End-stage HCM: incidence 3.5 %
- Complications: sudden death, progressive heart failure, apical aneurysm, stroke.
- Surgical treatment: (1) septal myectomy; (2) septal alcohol ablation.
- Postsurgical evaluation: (1) In patients with septal myectomy generally we observe a reduction thickness of basal septum; (2) evaluation of left outflow tract after myectomy is necessary in order to establish new gradients of pressure; (3) alcohol septal ablation causes necrosis in various regions of left ventricle; generally we observe areas of necrosis located in inferior basal septum.

Suggested Reading

Hunt SA et al (2005) ACC/AHA 2005 guideline update for the diagnosis and management of chronic heart failure in the adult. Circulation 112:e154–e235

Maron BJ et al (2013) Hypertrophic cardiomyopathy. Lancet 381:242–255

Warnes CA et al (2008) ACC/AHA 2008 guidelines for the management of adults with congenital heart disease. Circulation 118:e714–e833

I

Implantable Cardioverter Defibrillator

- ICD: device is able to recognize ventricular arrhythmias and deliver a shock to normalize cardiac pace.
- Patient at risk of sudden death.
- Absolute contraindication to MR.

Inferior Vena Cava Filter

- Indications: (1) anticoagulation contraindicated; (2) anticoagulation failure; (3) prophylaxis in high-risk patients.

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Inflammatory Aortic Aneurysm

- Characterized by the presence of perianeurysmal fibrosis and a thickened aortic wall.
- Represent 5–10 % of all abdominal aortic aneurysms; ascending aorta and aortic arch involvement is much less common, and when present there is a concomitant abdominal aortic aneurysm.
- Retroperitoneal extension of the inflammatory process is seen in one-third of affected patients, and it is responsible of secondary ureteral involvement with resultant hydronephrosis, aortic–sigmoid colon fistula with bleeding, and secondary bacterial infection.
- *CT*: (1) hypoattenuating mass with periaortic wall thickening that spares the posterior wall; (2) post-contrast enhancement of the soft-tissue component.
- *MR*: may detect periaortic inflammation, adventitial fibrosis, and turbulence in intraluminal flow.
- *FDG-PET*: identifies the extent of inflammation.

Interventricular Septum Movement

- Abnormal movement in RV volume and pressure overload and in case of abnormal electrical activity.
- Major causes of RV volume overload: (1) severe tricuspid or pulmonary regurgitation; (2) severe left-to-right shunt.
- Major causes of RV pressure overload: (1) severe pulmonary hypertension; (2) pulmonary stenosis.
- Systolic septal flattening/bouncing: RV pressure overload (RVOT obstruction, pulmonary hypertension).
- Early diastolic septal flattening: increased RV filling pressure, but still not pressure overload.

- Inspiratory septal bowing during early diastole: constrictive pericarditis.
- D-shape: RV overload (left-to-right shunt, tricuspid, or pulmonary regurgitation).
- Paradoxical septal movement: abnormal electrical activity (LBBB).

Intra-aortic Balloon Counterpulsation

- Catheter with a balloon positioned in the descending thoracic aorta which inflates in diastole and deflates in systole.
- Effects: (1) increases diastolic coronary perfusion; (2) reduces LVED pressure; (3) reduces myocardial oxygen consumption; (4) increases cerebral and peripheral blood flow.
- Indications: (1) cardiogenic shock post-MI; (2) acute severe mitral regurgitation; (3) preoperative; (4) weaning from cardiopulmonary bypass.
- Complications: (1) aortic dissection; (2) aortic regurgitation; (3) thrombocytopenia; (4) limb ischemia; (5) peripheral embolism.

Intramural Hematoma

- IMH: crescent-shaped thickening of the wall of the aorta that showed higher attenuation than that of the lumen on the unenhanced CT image or blood catabolite signal in MR, having no contrast enhancement in the aortic wall on the CT/MR image obtained after contrast enhancement.
- 10–20 % of patients with clinical features of aortic dissection exhibit an IMH.

- Same mortality of aortic dissection and should be treated in the same way.
- *Differential diagnosis*: dissection with completely thrombosed false lumen.

Intravascular Ultrasound

- A miniaturized ultrasound probe attached to distal end of an angiographic catheter.
- Gold standard for coronary wall evaluation and in vivo atherosclerotic plaque analysis.

Inversion Time

- LE: from 250 to 320 ms after 7 to 20 min from contrast medium injection.
- EG: 460 ms after 2–5 min from contrast medium injection.
- Null point: zero signal from myocardium.
- Bright myocardium: inversion time is too high.

Iodine

- Risk of severe anaphylactic reaction: ~1/2 in 10,000.
- Should be avoided in patient with renal impairment (GFR <30 ml/min) for the risk of contrast-induced nephropathy or dialysis should be planned.
- Premedication in adult patients at risk: 50 mg prednisone per os 13, 7, and 1 before the injection and antihistamine drugs (1 mg/kg) intravenous within 1 h of the injection.

Iron Overload, Myocardial

- Hereditary or acquired.
- Acquired: repeated transfusion in patient with hematological disorders (e.g., thalassemia, myelodysplasia).
- Iron accumulated in the liver and heart.
- $T2^*$ imaging can detect iron overload.
- Iron loading reduce tissue $T2^*$ with lower signal intensity.
- Measure $T2^*$ from the septum to reduce artifacts.
- $T2^*$ values at 1.5 T: <20 ms, significant overload; <10 ms severe overload.
- *MR*: (1) ventricular dilatation and dysfunction; (2) severity of iron overload.
- Liver overload demonstrated with biopsies does not correlate well with myocardial overload.

Ischemic Heart Disease

- Disease characterized by ischemia (reduced blood supply) of the heart muscle, usually due to coronary artery disease.
- *Characteristics*: (1) contractile dysfunction; (2) inducible perfusion defects; (3) infarction.
- *CT*: CAD detection.
- *MR*: inducible perfusion defects and myocardial infarct detection.
- *Differential diagnosis*: (1) dilated cardiomyopathy; (2) myocarditis; (3) valve disease; (4) other cardiomyopathies.
- See also *Myocardial Infarction*.

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J

Jatene Procedure

- Arterial switch operation in patients with transposition of the great arteries.
- Aorta and pulmonary arteries are separated from the ventricles and reattached in the correct position with coronary artery reimplantation.
- Long-term complication: outflow tract stenosis.
- Lecompte maneuver: variant in which the pulmonary artery is brought anterior the aorta. Long-term complication: pulmonary artery stenosis.

Suggested Reading

Warnes CA et al (2008) ACC/AHA 2008 guidelines for the management of adults with congenital heart disease. Circulation 118:e714–e833

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K

Kartagener's Syndrome

- Genetic autosomal recessive disease.
- Clinical triad: situs inversus, immotile cilia, and abnormal frontal sinuses.
- Symptoms: recurrent respiratory infections, bronchiectasia, sinusitis, and infertility.

Kawasaki's Disease

- Idiopathic vasculitis that affects children characterized by the formation of arterial aneurysms (e.g., axillary, popliteal, and coronaries).
- Coronary aneurysms may cause myocardial ischemia or infarcts.
- Antiaggregant therapy is always needed and anticoagulation is added when aneurysm caliber is >8 mm.

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- Complications: (1) aneurysm thrombosis and embolus; (2) myocardial infarcts; (3) vessel stenosis and occlusion.
- *MR*: (1) angiography study of the aorta and principal branches for vascular evaluation; (2) coronary MRA for coronary aneurysm detection and evaluation.

Keshan Disease

- Acquired deficit of selenium.
- Rare fatal cardiomyopathy in children.

Konno Operation

- Reconstruction of LV outflow tract in patients with tunnellike subvalvular obstruction.
- A patch in the interventricular septum is positioned and aortic valve is replaced.
- Aortic annulus and ascending aorta are also enlarged.

Suggested Reading

Holloway BJ et al (2011) Imaging of thoracic aortic disease. Br J Radiol 84:S338–S354

Warnes CA et al (2008) ACC/AHA 2008 guidelines for the management of adults with congenital heart disease. Circulation 118:e714–e833

L

Late Gadolinium Enhancement

- Gadolinium dose: 0.1 mmol/Kg.
- 7–20 min after contrast medium administration.
- TI: 250 – 320 ms.
- Cardiac planes: 4CH, 2CH, SA.
- Detection of (1) fibrosis, (2) necrosis, (3) inflammation, and (4) cardiac infiltration (e.g., amyloidosis).

Lecompte Maneuver

- Part of the arterial switch operation in TGA patients.
- Pulmonary artery is brought anterior to the ascending aorta.
- Major complication: pulmonary artery stenosis.
- See also *Transposition of Great Arteries*.

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Left Superior Vena Cava

- Prevalence: 0.3 %.
- 90 % bilateral SVC (bridging innominate vein common), 10 % only left SVC.
- Isolated finding or associated with other congenital abnormalities (ASD, VSD, aortic coarctation).
- No clinical significance if venous drainage occurs in the right chamber (usually left SVC drains in the coronary sinus).
- PMK/ICD insertion can cause significant problem in case of left SVC.

Leiomyosarcoma

- Rare malignant cardiac tumor.
- Primary involvement of left atrium.
- *MR*: (1) myocardial invasion; (2) intense contrast enhancement; (3) pericardial effusion and enhancement.
- *Differential diagnosis*: myxoma.

Libman–Sacks Syndrome

- Cardiac manifestation of systemic lupus erythematosus.
- Sterile vegetation of aortic and mitral leaflets.
- Regurgitation most common than stenosis.

Lipoma

- Well-defined sessile or pedunculated intracardiac mass.
- *MR*: (1) homogeneous high signal on T1w and signal drop with fat suppression; (2) no contrast enhancement.

Lipomatous Hypertrophy, Septal

- Benign lipomatous infiltration and expansion of the interatrial septum.
- *MR*: similar characteristics to lipoma.

Liposarcoma

- Rare malignant cardiac tumor with predominantly the involvement of the atrium.
- *MR*: large multilobulated mass with areas of hemorrhage and necrosis.

Loffler's Syndrome

- See section "Myocarditis, Eosinophilic".

Lyme Disease

- Disease caused by spirochete Borrelia burgdorferi.
- Direct involvement of cardiac muscle with AV conduction abnormalities and LV dysfunction.

Lymphoma

- Primary cardiac lymphoma is very rare.
- Cardiac involvement of noncardiac lymphoma in 25 % of patients.
- *MR*: (1) nodular infiltrative myocardial mass without area of hemorrhage or necrosis and variable contrast enhancement; (2) multiple cardiac lesions.

Lutembacher's Syndrome

- Combination of mitral stenosis (congenital or acquired) and atrial septal defect.

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M

Magnetohydrodynamic Effect

- Anomalous voltage detected by ECG caused by ions in the blood influenced by the magnetic field.
- Leads to ECG alterations on the T waves, which appears largest.

Major Aortopulmonary Collateral Arteries

- MAPCAs: arteries originating from descending aorta and transverse aortic arch to vascularize the lungs.
- Usually associated with pulmonary atresia and ventricular septal defect.
- Describe origin caliber, course, relationship with airways, and pulmonary territories supplied.
- Abrupt reduction in caliber of MAPCAs is protecting the pulmonary circulation from higher systemic pressure.
- MAPCAs visualization: CT > MR.

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Marfan Syndrome

- Autosomal dominant mutations in fibrillin gene.
- Incidence: 1/5,000–10,000.
- Cardiovascular anomalies: (1) ascending aorta dilatation with sinus of Valsalva involvement; (2) aortic dissection; (3) aortic valve regurgitation; (4) mitral valve prolapse and regurgitation; (4) main pulmonary artery dilatation; (5) mitral annulus calcification; (6) descending thoracic and abdominal aorta dilatation or dissection.
- See also *Aortic Aneurysm*, *Thoracic*.

Microvascular Obstruction

- Also known as "no-reflow phenomenon."
- Area of low signal intensity within the enhanced region of myocardial infarction (LE or early enhancement imaging).
- Predictive of adverse ventricular remodeling and major adverse cardiovascular events after MI.

Milliampere

- Tube current time product (mAs: milliampere second).
- Radiation dose is directly proportional to mAs and it can be adjusted customizing amperage values for body mass.
- Typical values in cardiac CT: 350 mAs in small patients, 450 mAs in medium-sized patients, and 550 mAs or higher in large patients.

Mitral Valve

- Two leaflets: anterior and posterior; normal leaflet thickness is less than 5 mm.
- Each leaflet consists of three segments: P1, P2, and P3 in the posterior and A1, A2, and A3 in the anterior.
- Normal annulus area: 4–6 cm^2.
- Chordae are attached to two papillary muscles that arise from the lateral wall of the left ventricle; the thickness of the chordae tendineae ranges from 0.4 to 1.2 mm.
- *CT*: assessment of leaflet, chordae, and papillary muscle morphology, thickening, and calcifications.
- *MR*: (1) morphological assessment; (2) leaflet motility; (3) flow evaluation.

Mitral Valve, Prolapse

- Systolic displacement of mitral valve leaflets below the mitral annulus plane of 2 mm or greater toward the left atrium.
- 2–3 % of general population.
- Two types: (1) billowing (bowing of leaflet body), the most common cause is myxomatous degeneration, and (2) flail leaflet (prolapse of the free edges of the leaflet beyond the mitral annulus plane of 2 mm or greater into the left atrium), due to chordal rupture in the presence of rheumatic disease or by infective endocarditis.
- Leaflet thickening: >2 mm.
- Association with perivalvular ventricular and papillary muscle fibrosis.
- Increased risk to develop infective endocarditis and arrhythmias or sudden death.

Mitral Valve Regurgitation

- Causes: (1) acute, bacterial endocarditis and myocardial infarction with involvement of the papillary muscle and (2) chronic, rheumatic heart disease, mitral valve prolapse syndrome, Marfan syndrome, congenital disease, idiopathic hypertrophic subaortic stenosis, functional (secondary to dilatation of the mitral annulus in LV dilatation).
- Types of regurgitation: (1) central regurgitation, due to coaptation failure or to annular dilatation, is located between A2 and P2, and (2) eccentric regurgitation, caused by prolapse, papillary dysfunction/failure, holes in the valve leaflets due to endocarditis, or degeneration.
- *CT*: (1) direct planimetry of the regurgitant orifice area; (2) direct evaluation of mitral leaflets, chordae tendineae, and papillary muscles; (3) other findings: compensatory left atrial dilatation, left ventricular dilatation, and pulmonary congestion.
- *MR*: (1) planimetry; (2) flow analysis; (3) multiple cine images perpendicular to the mitral valve commissure to assess scallops/coaptation and to identify the site of prolapse/regurgitation; (4) assessment of left atrial dimension; (5) thrombus detection.
- Indirect regurgitation quantification: (1) LVSV–aortic systolic flow (measured by aortic flow mapping); (2) LVSV–RVSV in isolated mitral regurgitation.

Table 1 Degree of mitral valve regurgitation

Mitral valve regurgitation		
Degree	Regurgitation fraction (%)	Regurgitation volume (ml/beat)
Mild	<30	<30
Moderate	30–49	30–59
Severe	>50	>60

Mitral Valve Stenosis

- Fusion of the edges of the anterior and posterior leaflets along the commissures.
- Causes: (1) congenital (parachute mitral valve); (2) rheumatic heart disease (most common); (3) thrombus; (4) myxoma; (5) tumor.
- *CT*: (1) funnel shaped with thickened and calcified leaflets; (2) restricted opening of the thickened valve from commissural fusion; (3) "fishmouth" appearance on SA images; (4) bowing of a thickened and fibrotic anterior leaflet during diastole results in a "hockey-stick" appearance.
- *MR*: (1) peak velocity calculation; (2) left atrial enlargement; (3) RV dysfunction; (4) pulmonary regurgitation; (5) atrial thrombus.

Myxoma

- Most common benign cardiac tumor.
- Usually in the left atrium (75–80 %), right atrium (15–20 %), and left ventricle (5 %).
- *Characteristics*: (1) pedunculate mass arising from the interatrial septum; (2) high mobility with typical prolapse through valvular orifice.
- *MR*: well-defined mass with heterogeneous signal intensity.
- *Differential diagnosis*: thrombus.

Table 2 Degree of mitral valve stenosis

Mitral valve stenosis		
Degree	Area (cm^2)	Mean gradient (mmHg)
Mild	1.6–3.9	<5
Moderate	1.0–1.5	5–10
Severe	<1.0	>10

Mustard Procedure

- Also known as atrial switch for TGA intact septum.
- Baffle obstruction and leak are responsible of systemic blood desaturation.
- RV performance decays over years because of systemic pressure.
- *MR*: (1) through-plane flow at the level of SVC and IVC; (2) cine sequences of superior and inferior baffles; (3) pulmonary vein obstruction; (4) LGE of systemic thickened RV.

Myocardial Infarct

- Three clinical categories: (1) acute coronary syndrome with clinical MI, troponin raising >1 ng/mL or high-sensitivity TnI >0.5 ng/ml (usually patients with complete coronary occlusion, LV dysfunction, and ECG alterations (ST elevation, ST depression, T wave inversion). Risk of death, 12–15 %); (2) acute coronary syndrome with myocardial necrosis, troponin raising <1 ng/mL (usually patients with coronary thrombus and some degree of LV dysfunction. Risk of death, 8–12 %); (3) acute coronary syndrome with unstable angina, troponin not raised with transient ECG alterations (ST elevation or ST depression) (low risk of death).
- Complete necrosis of all myocardial cells in the area at risk: at least 2–4 h or longer.
- *CT*: (1) coronary occlusion/stenosis; (2) LV dysfunction; (3) regional akinesia/hypokinesia.
- *MR*: (1) LV dysfunction; (2) regional akinesia/hypokinesia; (3) myocardial edema; (4) myocardial LE.
- See also *Acute Aortic Syndrome* and *Troponin*.

Table 3 MR/CT myocardial viability assessment

Viability assessment	
LE extension (% of wall thickness)	Functional recovery likelihood (%)
0	80
1–25	40
26–50	60
51–75	10
76–100	~0

Myocardial Viability

- Can be assessed with stress echo, SPECT, PET, and MR.
- *MR*: (1) late enhancement; (2) low-dose dobutamine stress.
- *MR*: (1) LE transmural extent is predictive of the functional recovery after revascularization; (2) viability cutoff: 50 % of transmural LE; (3) low-dose dobutamine stress can be useful in borderline cases (transmural LE 25–75 %).

Myocarditis

- Inflammation of the myocardium of complex etiology (infectious, autoimmune, or toxic etiologies).
- Classification: (1) acute, subacute, and chronic; (2) focal or diffuse.
- *MR*: (1) LV function can be normal or reduced; (2) myocardial edema is a specific sign of acute myocardial injury; (3) LE: subepicardial layer of myocardium. Predominant pattern of LE is on lateral free wall of left ventricle. LE absence does not exclude the diagnosis; (4) Pericardial effusion is not specific for myocarditis but could represent a sign of acute inflammation.

- Echo/MR follow-up needed: acute viral myocarditis could shift in chronic myocarditis and subsequently cause a dilative cardiomyopathy.
- *Differential diagnosis*: acute myocardial infarct, cardiomyopathies, infiltrative disease, sarcoidosis, drugs (chemotherapy).

Myocarditis, Eosinophilic

- Endomyocardial inflammation associated with high levels of circulating eosinophils.
- It can occur in various conditions (Churg–Strauss syndrome, Loeffler's endocarditis, endomyocardial fibrosis).
- *Characteristics*: Endomyocardial inflammation occurs in the endocardium around the apex, with consequent circumferential involvement of mid-ventricle and papillary muscles.
- Acute form: eosinophilic vasculitis leading to dilated cardiomyopathy.
- Chronic form: myocardial fibrosis leading to restrictive cardiomyopathy.
- Diagnosis: endomyocardial biopsy.
- *MR*: (1) reduced LV function with mid-apical concentric hypertrophy; (2) endomyocardial edema; (3) apical thrombus; (4) circumferential subendocardial LE of the apex and mid-ventricle.
- *Differential diagnosis*: Cardiac amyloidosis, any restrictive cardiomyopathy.

Myocarditis, Tubercular

- Rare condition.
- The right chambers are the most involved.

- Three patterns of disease have been described: (1) tuberculoma, (2) diffuse infiltrative, and (3) diffuse miliary.
- *MR*: Tuberculoma is iso-/hypointense on T1- and T2-weighted images and shows a dishomogeneous enhancement after the administration of contrast agent.
- Presentation of diffuse infiltrative and miliary patterns is similar to other myocarditis.

Myocardium, Hibernating

- State of persistently impaired myocardial contractility due to chronically reduced coronary blood flow.
- It can be restored to normal by improving blood flow after surgical/percutaneous revascularization.

Myocardium, Stunned

- State of impaired myocardial contractility which can persist for variable period of time after acute ischemia showing a gradual recovery also in the absence of surgical/percutaneous revascularization.

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N

Nephrogenic Systemic Fibrosis

- Severe systemic disease involving fibrosis and contracture of internal organs and skin.
- Correlation between gadolinium contrast and patient with severe renal dysfunction (GFR <30 ml/min).
- 5 % of patients have a rapidly progressive course that may result in death.
- No reports of NSF in patient with GFR >30 ml/min.
- No successful treatment exists.

Noncompaction Cardiomyopathy

- Diffuse trabeculation of the endocardial layer with thinned epicardial layers.
- Possible etiopathogenesis: myocardial compaction failure in fetal heart.
- Complications: cardiac failure, sudden cardiac death, thrombus, arrhythmias.

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- *MR*: (1) increased LV trabeculation (diffuse or segmental); (2) LV/RV dilatation with impaired contraction; (3) LV thrombus; (4) LE can be present.
- An end-diastolic ratio of noncompacted/compacted myocardium ≥2.3 defines the condition.
- In borderline cases, repeat MR at 12 months to assess ventricular remodeling.
- Treatment: ICD implantation.
- *Differential diagnosis*: dilated cardiomyopathy, hypertrophic cardiomyopathy, normal variant (usually no symptoms, LV dilatation, or systolic contraction).

Noonan's Syndrome

- Congenital dysmorphic syndrome characterized by pulmonary valve stenosis, short stature, deafness, and hypertelorism.

Norwood Operation

- Palliative intervention for the treatment of hypoplastic left heart syndrome with aortic atresia and hypoplasia of the ascending aorta.
- Reconstruction of neo-ascending aorta using pulmonary trunk and valve and creation of aortopulmonary shunt (Blalock–Taussig or Waterston shunt).

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O

Osteosarcoma

- Rare malignant cardiac tumor.
- More frequent in left atrium.
- *CT*/*MR*: invasive characteristics with common intratumoral calcifications.

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P

Pacemaker

- Can pace and sense in one, two, or three chambers.
- Two types of lead: unipolar or bipolar.
- International codes: first letter, chamber paced (V = ventricle, A = atrium, D = dual); second letter, chamber sensed (V = ventricle, A = atrium, D = dual); third letter, how the device responds to the event (I = inhibits, T = triggers, D = dual, O = nothing). A fourth letter can be present to describe added features.
- Ventricular lead placed most commonly in RV apex, RVOT, or on septum.
- Atrial lead placed in the right atrial appendage.
- Indications: (1) symptomatic complete heart block; (2) symptomatic second-degree heart block; (3) bifascicular block with intermittent third-degree block, second-degree block, or BBB; (4) trifascicular block with intermittent third-degree or second-degree block; (5) symptomatic sinus node dysfunction; (6) symptomatic chronotropic incompetence; (7) carotid sinus hypersensitivity; (8) sustained VT caused by pauses; (9) drugs that result in symptomatic bradycardia.

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- Absolute contraindication to MR. In particular circumstance when the scan is vital the MR examination could be performed after accurate situation assessment under strictly monitorization.
- New MR-compatible pacemaker is recently available.

Paravalvular Abscess

- Complication of bacterial endocarditis
- The aortic valve ring is more frequently affected than the mitral valve.
- *MR*: (1) heterogeneous low signal on T1w and high SI on T2w; (2) contrast enhancement; (3) cine images are helpful to detect the presence of communication between the abscess cavity and the cardiac chambers.

Perfusion Imaging, Myocardial

- Techniques: echocardiography, SPECT, PET, MR, CT.
- Pharmacological agents: (1) vasodilators (adenosine, dipyridamole, regadenoson); (2) beta-agonist (dobutamine).
- Myocardial perfusion reserve: the ratio of regional myocardial blood flow after induced vasodilatation to that under resting conditions (cutoff value: 1.5).
- *CT perfusion*: (1) dynamic acquisition, absolute quantitative assessment; (2) single-energy or dual-energy helical acquisition, semiquantitative assessment.
- *MR perfusion*: (1) dynamic acquisition, absolute quantitative assessment.

- Qualitative interpretation: presence of subendocardial or transmural hypointense rim during the "first pass" of contrast.
- Semiquantitative interpretation: measurement of myocardial perfusion reserve.
- Quantitative interpretation: measurements of regional myocardial blood flow (in ml/g/min) using time–intensity curve deconvolution with a measured arterial input function (usually from the left ventricular cavity or ascending aorta).
- See also *Adenosine*, *Dobutamine*, *Dipyridamole*, and *Regadenoson*.

Pericardial Cyst

- Most common location is right cardiophrenic angle (80 %).
- *CT*/*MR*: (1) thin wall, without septa; (2) no contrast enhancement; (3) compression of adjacent structures.
- *Differential diagnosis*: hydatid disease, extracardiac cyst, pericardial tumor.

Pericardial Effusion

- Causes: (1) pericarditis; (2) cardiac failure; (3) malignancy; (4) uremia; (5) iatrogenous after percutaneous cardiac procedure.
- Pericardial effusion is not specific for myocarditis but could represent a sign of acute inflammation.
- *MR*: high sensitivity and allows individuation of effusion small as 30 ml.
- See also *Pericarditis*, *Acute*.

Pericardial Metastases

- Causes: lung, breast, melanoma, esophagus, leukemia, multiple myeloma, lymphoma, and thymoma.
- *CT*/*MR*: (1) pericardial effusion; (2) irregular thickening or pericardial mass; (3) lesion contrast enhancement.

Pericardial Neoplasms

- Common benign tumors: lipoma, teratoma, fibroma, hemangioma, lymphangioma, neurofibroma, paraganglioma, and granular cell myoblastoma.
- Malignant tumors: pericardial metastasis (10–12 % of patients with malignancy), pericardial mesothelioma.
- See also *Pericardial Metastasis*.

Pericarditis, Acute

- Acute inflammation of pericardium with or without pericardial effusion.
- *CT*: (1) pericardial effusion (transudate, 0–25 HU; exudate, >25 HU); (2) pericardial thickening or irregularity of pericardial contour.
- *MR*: (1) pericardial effusion (transudate: T1w hypointense and T2w hyperintense; exudate: T1w and T2w hyperintense); (2) pericardial edema; (3) pericardial and adjacent myocardium LE.

Pericardium, Congenital Absence

- Complete: (1) heart displaced laterally and posteriorly; (2) dilated RV; (3) lung tissue interposition between base of the heart and diaphragm.
- Partial: ventricular indentation.
- Usually asymptomatic, but LV herniation is possible in partial absence with arrhythmias and chest pain.

Peripartum Cardiomyopathy

- Development of cardiac failure between the last month of pregnancy and 5 months postpartum in the absence of any identifiable cause or recognizable heart disease prior to the last month of pregnancy and LV systolic dysfunction.
- Full recovery in 50 % of cases.

Plaque Composition

- Lipid plaque: instable with higher risk of rupture.
- Calcified plaque: stable.
- *CT*: (1) predominantly lipid-rich plaques, ≤60 HU; (2) intermediate plaques, 61–119 HU; (3) predominantly calcific plaques, ≥120 HU.

Pott's Shunt

- Surgical anastomosis between descending aorta and left pulmonary artery.

Prinzmetal Angina

- Also known as variant angina.
- Angina due to coronary spasm.
- More frequent in younger women.
- Diagnosis: coronary angiography with the injection of provocative agents, an exaggerated coronary spasm is suggestive for the diagnosis.

Prosthetic Valves

- Two major groups of artificial valves: (1) mechanical and (2) bioprosthetic.
- Patients with prosthetic valves can safely undergo CMR (also Starr–Edwards).
- Complications: (1) endocarditis; (2) valve dehiscence and paravalvular abscesses; (3) paraprosthetic or transvalvular (usually bioprosthetic) regurgitation.
- Bioprosthetic valve has less risk for early endocarditis than mechanical.
- A negative echocardiogram may not exclude endocarditis, and MR/CT is more sensitive.
- MR may be susceptible to metallic artifacts reducing the image quality (FLASH sequence less prone to artifacts than SSFP).

Pulmonary Arteries

- Main pulmonary artery diameter: <30 mm.
- Left pulmonary artery is normally overriding the left bronchus and the right pulmonary artery is usually coursing below the right upper lobe bronchus. Useful in isomerism.
- A larger MPA might be related to pulmonary hypertension or systemic to pulmonary shunts (ASD, APVR).
- Anomalies of caliber origin and course of branch pulmonary arteries are common on congenital heart disease, such as ToF, pulmonary atresia, truncus arteriosus.
- Tortuosity and "pruning" aspect of peripheral branch pulmonary arteries in keeping with pulmonary hypertension.

Pulmonary Artery Aneurysm

- Causes: (1) vasculitis, Behçet's syndrome with typical right lower lobe arteries aneurysm with frequent thrombosis and surrounding inflammation; (2) infections, postprimary tuberculosis, pyogenic bacteria, mycotic pulmonary aneurysms, and pseudoaneurysms; (3) neoplasm, primary pulmonary arteries tumor, or pseudoaneurysms caused by erosion from primary lung cancer and pulmonary metastasis; (4) trauma, malpositioned Swan-Ganz catheters are an increasingly common cause of iatrogenic pulmonary artery pseudoaneurysms.
- Clinical presentation is mostly nonspecific and includes hemoptysis, dyspnea on exertion, fever or cough, and chest pain.

Pulmonary Artery Dissection

- Extremely rare, usually iatrogenic post cardiac catheterization.
- Spontaneous dissection always occurs at the site of a pulmonary aneurysm or dilation.

- In case of Rastelli procedure or RV–PA conduit, it is possible to have neointimal dissection (peel dissection).
- The false lumen tends to rupture rather than to develop a reentry site, unlike aortic dissection.
- Symptoms are nonspecific: dyspnea, retrosternal chest pain, and central cyanosis.

Pulmonary Artery Tumors

- Very rare; the most frequent is sarcoma.
- Uncommon cause of intraluminal arterial filling defect.
- *CT*: unilateral, lobulated, heterogeneously enhancing masses forming acute angles with the vessel wall.
- *Differential diagnosis*: (1) acute pulmonary embolism, does not demonstrate enhancement; (2) chronic pulmonary embolism demonstrates enhancement but forms obtuse angles with the vessel wall.

Pulmonary Atresia

- Atresia of part or all of the central pulmonary arteries with lack of continuity between the right ventricle and the pulmonary arteries, associated with ventricular septal defect.
- The blood supply to the lungs originates from extracardiac sources, most commonly from PDA or MAPCAs, which connect the systemic circulation with the pulmonary arteries.
- *CT*/*MR*: (1) length of the pulmonary atresia; (2) presence of pulmonary artery confluence; (3) size of main, right, and left pulmonary arteries; (4) branch pulmonary artery stenosis;

(5) pulmonary blood flow to each lung; (6) number of bronchopulmonary segments supplied by native pulmonary arteries and the distribution of each major aortopulmonary collateral arteries.

Pulmonary Arterial Hypertension

- Nonpregnant elevation of mean pulmonary artery pressure ≥25 mmHg at rest or ≥30 mmHg on exercise, in absence of left-to-right shunt.
- RV function is an important prognostic indicator in PAH.
- *CT*/*MR*: (1) RV function volumes; (2) pulmonary artery stiffness; (3) increased pulmonary artery diameters.
- *MR*: LE in junctional zone secondary to increased septal stress.
- See also *Eisenmenger Syndrome*.

Pulmonary Valve Regurgitation

- Causes: (1) pulmonary hypertension; (2) infective endocarditis; (3) iatrogenic (ToF repair); (4) congenital malformations; (5) trauma; (6) carcinoid; (7) rheumatic heart disease.
- *CT*: (1) leaflet morphology and thickening; (2) incomplete leaflet coaptation in the end-systolic phase; (3) evaluate the presence of reflux of contrast material into the inferior vena cava and hepatic veins during the first pass of contrast material.
- *MR*: (1) leaflet morphology and thickening; (2) incomplete leaflet coaptation; (3) quantitative flow measurements.

Table 1 Degree of pulmonary valve regurgitation

Pulmonary valve regurgitation	
Degree	Regurgitation fraction (%)
Mild	<25
Moderate	25–50
Severe	>50

Pulmonary Valve Stenosis

- *Causes*: (1) congenital (95 % of cases); (2) rheumatic; (3) carcinoid.
- *CT/MR*: (1) Poststenotic enlargement of the main and the left pulmonary arteries and right ventricular hypertrophy; (2) decreased mobility of valve leaflets and incomplete opening; (3) bowing of the interventricular septum to the left.
- *MR*: quantitative flow measurements:
  - Peak velocity, forward stroke volume, and mean transvalvular gradients.
  - In-plane velocity mapping is useful to identify, whereas the jet starts, in order to distinguish between supravalvular, valvular and subvalvular stenosis.
- *Differential diagnosis*: (1) supravalvular stenosis, congenital or iatrogenic (uncommon); (2) RVOT obstruction.
- See also *RVOT Obstruction*.

Pulmonary Veins

- Two right and two left pulmonary veins, draining to the posterior face of the left atrium.
- A frequent anatomical variation is the presence of common left trunk.

Table 2 Degree of pulmonary valve stenosis

Pulmonary valve stenosis			
Degree	Area (cm^2)	Mean gradient (mmHg)	Peak velocity (m/s)
Mild	>1.0	10–25	<2.5
Moderate	0.5–1.0	25–40	2.5–3.2
Severe	<0.5	>40	>3.2

- Orifice diameter at the venoatrial junction: 8–21 mm.
- *CT*/*MR*: (1) Before radiofrequency ablation, assess anatomy and anatomical variants and sizes of the pulmonary vein ostia and exclude the presence of thrombi and tumors; (2) after radiofrequency ablation, evaluate the presence of complications (stenosis, infarction, perforation and hematoma of the pulmonary veins).
- Quantitative flow measurements:
  - Flow analysis through each pulmonary vein.
  - PC sequences obtained without breath hold because the venous flow pattern can change significantly with breath holding.
  - The normal pulmonary venous flow curve consists of systolic and diastolic forward waves and a late diastolic reversed wave on atrial contraction.

Pulmonary Vein Atresia

- Localized or diffuse hypoplasia or atresia of one or more pulmonary veins, isolated or in association with congenital heart disease or after surgery.
- The clinical presentation depends on the number of involved veins and the degree of the obstruction.
- Pulmonary hypertension may occur.

- *MR/CT angiography*: both show pulmonary veins better than echocardiography, in particular beyond the neonatal period.
- *MR*: (1) pulmonary vein flow dynamics; (2) differential pulmonary arterial flow.

Pulmonary Venous Drainage, Anomalous

- Congenital cardiac disease in which the cardiac veins drain in the systemic venous system usually with a common trunk associated with an ASD.
- Two forms: (1) partial and (2) total.
- Partial anomalous drainage: most common, drainage of the right pulmonary veins to SVC (large left-to-right shunt).
- Total anomalous drainage: (1) supracardiac, the common trunk drains into the innominate vein; (2) infracardiac, the common trunk drains into the IVC, portal vein, or hepatic veins; (3) cardiac, the common trunk drains into the coronary sinus or right atrium.
- Surgical correction: connection of the common trunk with the LA and ASD closure.
- Postsurgical complications: (1) postsurgical obstruction of the pulmonary trunk or atrial connection; (2) residual ASD.
- *CT*: (1) Advantageous in critically ill neonates with obstructive TAPVR, because of accuracy, very short imaging times, and no need for sedation; (2) ECG-gated acquisition are usually not necessary because venous structures are not very sensitive to cardiac motion.
- *MR*: (1) Evaluation of the status of pulmonary and systemic vasculatures; (2) transaxial cine images with 3–4 mm section thickness; (3) a complete study includes measurement of the volume and blood flow velocity of the abnormal venous drainage, pulmonary-to-systemic blood flow ratio (Qp/Qs), description of the secondary effects on pulmonary arterial

size and blood flow, and ventricular size and function; (4) CEMRA for the assessment of the number and drainage of involved veins; (5) quantification of the left-to-right shunt and right heart size; (6) demonstration of aortopulmonary collateral vessels.

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Q

Q Fever

- Caused by Coxiella burnetii.
- See also *Infective Endocarditis*.

Qp/Qs

- Pulmonary flow (Qp) and systemic flow (Qs) ratio.
- The normal ratio is 1.0.
- Qp/Qs value between 0.9 and 1.1 is considered normal, although a minimal shunt can be present (e.g., PFO).
- Increased Qp/Qs ratio: ASD, VSD, and anomalous pulmonary venous return.
- Reduced Qp/Qs ratio: PDA, MAPCAs, or systemic to pulmonary shunt.
- Normal Qp/Qs: pulmonary AVM.
- *MR*: (1) Accurate evaluation of Qp/Qs; (2) use phase contrast technique above aortic and pulmonary valves to obtain a reliable Qp/Qs measure; (3) Qp/Qs evaluation with stroke

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volume technique is not reliable in case of mitral/tricuspid regurgitation; (4) MR can misdiagnose PFO; the gold standard is transcranial Doppler; (5) for other shunts, the gold standard is cardiac catheterization; (6) always think about a shunt when there is RV dilatation with no evidence of valvular disease.

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R

Rastelli Procedure

- Generally indicates interposition of an extra-anatomic conduit between RV free wall and pulmonary arteries (confluence or MPA).
- In case of TGA and unrestrictive VSD (± pulmonary stenosis), the LVOT is tunneled to the aorta through the large VSD (aortic tunnel or baffle). The native pulmonary artery is closed and the Rastelli conduit is interposed, preferably to the left of the aorta but always depending on the congenital anatomy.
- Always look for pulmonary conduit obstruction/regurgitation.

Regadenoson

- Vasodilator agent used in myocardial stress perfusion.
- A_{2a} adenosine receptor agonist.
- Vasodilatation without beta-adrenergic receptor stimulation.
- Can be used in patient with asthma or COPD.
- Half-life: 2–3 mins.

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- Single bolus administration.
- Dose: 0.4 mg at 5 ml/s.
- Contraindications: (1) high-grade AV block; (2) sinus bradycardia.
- Side effects: transient heart block, transient hypotension, transient tachycardia.
- Antagonist: aminophylline, 50–100 mg over 1 min, injection can be repeated up to 250 mg total dose.
- See also *Perfusion Imaging*, *Myocardial*.

Restrictive Cardiomyopathy

- Condition characterized by impaired diastolic dysfunction due to reduce ventricular compliance.
- Causes: (1) infiltrative myocardial disease: amyloidosis, sarcoidosis; (2) non-infiltrative myocardial disease: idiopathic, scleroderma; (3) myocardial storage disease: glycogen or lysosomal storage disease, hemochromatosis; (4) endomyocardial disease: hypereosinophilic syndrome, endomyocardial fibrosis, carcinoid, metastatic malignancy.
- *CT*/*MR*: (1) concentric hypertrophy; (2) biatrial enlargement; (3) pattern of late enhancement.
- *Differential diagnosis*: constrictive pericarditis, important to distinguish because pericarditis can be treated surgically.

Rhabdomyoma

- Most common benign cardiac tumor in infants and children, 50 % of cases associated with tuberous sclerosis.
- Multiple ventricular well-defined intramural mass.
- *MR*: isointense on T_1 and T_2 with homogenous contrast enhancement.

Rhabdomyosarcoma

- Most common malignant cardiac tumor in infants and children.
- Can involve any chamber, predilection for the valves.
- *CT*/*MR*: heterogeneous cystic mass with contrast enhancement.

Rheumatic Fever

- Caused by Streptococcus pyogenes usually after pharyngitis.
- *Characteristics*: pancarditis with mitral (70 %) and aortic involvement (25 %) causing chronic valvular stenosis.
- *CT*/*MR*: Mitral leaflets thickness with moderate-severe stenosis and LA enlargement.

Right Ventricle Dilatation

- Causes: (1) myocardial infarction; (2) pulmonary or tricuspid regurgitation; (3) ARVC; (4) left-to-right shunt; (5) idiopathic dilated cardiomyopathy; (6) other cardiomyopathies.
- RV volume overload: (1) pulmonary or tricuspid regurgitation; (2) severe left-to-right shunt.
- RV pressure overload: (1) pulmonary hypertension; (2) pulmonary stenosis.

Right Ventricular Outflow Tract Obstruction

- Causes: (1) congenital disease (ToF); (2) surgery; (3) LV/RV hypertrophy.
- *MR*: can help to differentiate between valvular and subvalvular stenosis.
- See also *Pulmonary Valve Stenosis*.

Ross Operation

- Aortic valve replacement with pulmonary autograft.
- Performed in children with severe aortic stenosis.
- Aortic root is removed and replaced with pulmonary root; meanwhile the pulmonary root is replaced by homograft from cadaver; coronaries are reimplanted on neo-aortic root.
- Often associated with Konno procedure (LVOT enlargement).
- Monovalvular illness is transformed into bivalvular, in order to avoid the positioning of mechanical valve resulting in anti-coagulation therapy or a biological valve which should be changed usually after 10 years.
- Aorta and the pulmonary artery must have the same caliber in order to be substituted and the pulmonary valve must be normofunctioning.
- Surgery is performed until 16 years and in some centers until 25–30 years.

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S

Sarcoidosis, Cardiac

- Systemic disease of unknown origin characterized by non-caseating granuloma.
- Clinical involvement of heart by sarcoidosis is 5 %, but autoptic studies detect sarcoidosis in 20–50 % of patients.
- *MR*: (1) Reduced LV function (global or regional); (2) patchy myocardial edema; (3) various patterns of late enhancement, early-stage epicardial/mid-wall involvement, late stage transmural; (4) RV can be involved.
- *Differential diagnosis*: cardiomyopathies, myocarditis, myocardial infarction.

Saturation Band

- *MR*: To reduce respiratory, pulsatility and flow artifacts put the saturation bands along phase encoding direction in LE, EG, and stress imaging.

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Scimitar Syndrome

- Abnormal connection of the right pulmonary vein to the IVC.
- Anomalous systemic arterial supply to the right lower lung.
- Right lung hypoplasia and sequestration.
- Associated lesions: VSD, ASD, PDA, coarctation.
- See also *Pulmonary Venous Drainage Anomalies*.

Senning Operation

- Atrial switch operation in patient with TGA.
- See also *Transposition of Great Arteries*.

Shimming

- Correction of inhomogeneity of the magnetic field produced due to imperfections in the magnet or to the presence of external ferromagnetic objects.
- If something wrong with the image, shim it!

Shunt

- See *ASD*, *VSD*, *PDA*, *PFO*.

Shunt, Surgical

- (1) Systemic to pulmonary artery shunts (Blalock–Taussig, Waterston); (2) cavopulmonary anastomosis (Glenn shunt); (3) right ventricle to pulmonary artery conduits.

Simpson Modified Rule

- To calculate ventricular volumes.
- Cross-sectional area of each LV short-axis segment x sequence thickness.

Sinus, Coronary

- Normal diameter: 10 mm.
- If dilated look for RV volume overload or persistent left SVC.

Starr–Edwards Valve

- See *Prosthetic Valve*.

Stent, Coronary

- Type: (1) drug-eluting stent; (2) uncoated metallic stent; (3) biodegradable nonmetallic stent.
- The rate of restenosis is 10 % with a drug-eluting stent and 40 % with an uncoated metallic stent.
- Before CT examination the stent type should be evaluated in order to know the artifact severity and the possibility to visualize the lumen.
- *CT*: (1) Neointimal hyperplasia is characterized by the presence of a darker rim between the stent and the contrast-enhanced vessel lumen. (2) The observation of distal runoff cannot be considered an absolute indicator of patency. The presence of vessel enhancement distal to the stent could also be secondary to retrograde filling. (3) Blooming artifact: results from beam hardening and causes underestimation of the in-stent luminal

diameter. (4) Sharp kernel-filtered images are less affected by blooming than the smooth kernel-filtered images. The use of a dedicated convolution kernel allows a significant decrease in the severity of blooming artifacts at the edges of high-attenuation structures. (5) Wide window settings are necessary for accurate evaluation of the in-stent lumen at CT angiography (window width, 1,500 HU; window center, 300 HU).
- *MR*: no contraindication in stented patient examination.

Stent, Coronary Biodegradable

- No risk of stent thrombosis and prolonged antiplatelet therapy.
- Suitable for complex anatomy and to avoid full metal jacket which may interfere with bypass graft surgery.
- Normal vessel motion and vasoreactivity restored after vessel healing.

Stent, Coronary Drug Eluting

- Lower rate of restenosis compared to uncoated stent.
- Complication: subacute and late coronary thrombosis.
- Drugs: sirolimus, paclitaxel.

Stroke Volume

- SV: EDV-ESV.
- It does not need to be indexed.

- LVSV must be equal to aortic flow in absence of aortic/mitral regurgitation.
- In normal structured hearts with competent valves, biventricular SVs must match.
- See also *Qp*/*Qs*.

Sudden Cardiac Death

- Non-traumatic, nonviolent, unexpected death due to cardiac causes within 1 h of the onset of symptoms.
- Most common causes in athletes: (1) hypertrophic cardiomyopathy; (2) commotio cordis; (3) coronary artery anomalies; (4) undetermined left ventricular hypertrophy; (5) myocarditis; (6) ruptured aortic aneurysm (Marfan syndrome); (7) ARVC.

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T

Takayasu Arteritis

- Also known as "pulseless disease."
- Necrotizing and obliterative large-vessel panarteritis, which affects mostly young women (80 %).
- Inflammatory process leads to occlusion and narrowing of the aorta and its branches.
- Aortic involvement is common, wherein the abdominal aorta is the most affected, followed by the descending thoracic aorta and aortic arch.
- Aneurysmal evolution and rupture of the affected aortic segments are not uncommon.
- *CT*/*MR*: in early-stage crescentic or ringlike aortic thickening of more than 3 mm.
- Numano Group Classification:
  - Type I: sovra-aortic vessels.
  - Type IIa: ascending aorta and/or aortic arch; sovra-aortic vessels may be affected.
  - Type IIb: descending aorta with/without ascending aorta and/or sovra-aortic vessel involvement.

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  - Type III: descending aorta, thoracic aorta, and/or renal artery involvement; no involvement of ascending aorta, aortic arch, and sovra-aortic vessels.
  - Type IV: abdominal aorta and/or renal arteries.
  - Type V: whole aorta involvement.
  - Note: coronary and pulmonary artery involvement is reported as C+and P+.
- *Differential diagnosis*: (1) large-vessel acute infections (mycotic aneurysm); (2) chronic infections (syphilis and TBC, especially in HIV patients); (3) radiation-induced fibromuscular dysplasia; (4) juvenile atherosclerosis.

Takotsubo Cardiomyopathy

- Acute onset of chest pain and completely reversible regional contractile dysfunction, usually in the LV apical region.
- Probably due to transient coronary vasospasm secondary to stressful condition.
- *MR*: (1) apical LV akinesia; (2) apical myocardial edema; (3) no LE.
- *Differential diagnosis*: acute myocardial infarct.

Tamponade, Cardiac

- Low or rapid accumulation of blood, fluid, gas, or neoplastic tissue in pericardial cavity.
- Classification: (1) acute; (2) subacute; (3) occult (low pressure).
- Characteristics: (1) diastolic collapse of RV free wall and RA (first sign of RA collapse but unspecific); (2) dilated IVC with no inspiratory collapse.

Taussig–Bing Syndrome

- Congenital disease in which the aorta arises from the right ventricle and the pulmonary artery arises from both ventricles associated with VSD.

Test Bolus

- To calculate CEMRA acquisition time: (contrast arrival time + 1/2 injection time) - center K space.

Tetralogy of Fallot

- Commonest cyanotic congenital cardiac disease.
- *Characteristics*: (1) large nonrestrictive VSD; (2) overriding aorta; (3) RVOT obstruction; (4) RV hypertrophy.
- The commonest cyanotic cardiac disease presenting outside the neonatal period.
- Overriding aorta: 50 % of the aorta is beyond the interventricular septal crest.
- Surgical repair: (1) VSD closure with Gore-Tex® or pericardium patch; (2) RVOT obstruction relief by transannular patching, valvectomy, or placing a homograft/conduit between the right ventricle and pulmonary artery.
- Surgical correction in infant with transannular or infundibular patch, depending on the anatomy.
- Dilatation of the RV in repaired tetralogy of Fallot is common and due to significant pulmonary regurgitation. Pulmonary valve implantation, either surgical or transcatheter, is needed in severe RV dilatation (iRVEDV > 150 ml/m^2) to avoid RV failure and malignant arrhythmias.

- Always look at branch pulmonary artery stenosis or dilatation quantifying the split pulmonary artery forward flow.
- Post-contrast 3D SSFP navigator sequence in sagittal acquisition to better understand intracardiac and thoracic congenital and postsurgical anatomy.
- Relationship between coronaries (particularly LCA) and RVOT is very important for percutaneous pulmonary valve implantation.

Thalassemia

- See *Iron Overload*.

Tissue Doppler Imaging

- TDI: echocardiography technique to assess the displacement of low velocity structure.
- Accurate way to assess regional ventricle wall motion or track mitral/tricuspid annular motion and correlate it with ventricular systolic function or relaxation.

Total Cavopulmonary Connection

- Palliative operation for patient with univentricular heart.
- IVC connected to pulmonary artery using an intra-atrial tunnel combined with a Glenn shunt to SVC.
- See also *Fontan Intervention*.

Transcatheter Aortic Valve Replacement

- TAVR: alternative treatment in high-risk patients with severe aortic stenosis and other comorbidities.
- A retrograde transarterial technique (femoral or subclavian artery) or an antegrade transapical implantation technique via the tip of the left ventricle is utilized.
- Optimal positioning of the transcatheter aortic prosthesis relative to the annulus is critical.
- Valve positioned too high: (1) increased risk of paravalvular regurgitation; (2) aortic injury; (3) embolization into the aorta.
- Valve positioned too low: (1) mitral valve dysfunction; (2) heart block; (3) paravalvular regurgitation; (4) embolization into the left ventricle.
- *CT*: (1) anatomic assessment of the aortic root structures; (2) course of the descending aorta and the iliofemoral access.
- Accurate analysis and measurement of the annulus are crucial for correct selection of prosthesis size and type and to avoid damage of the annulus.
- Complete evaluation of coronary anatomy with regard to the relationship between leaflet height and distance between annulus and coronary ostia, which identifies patients at risk for coronary occlusion during the procedure (a distance <10 mm).
- Aortic valve evaluation: tricuspid or bicuspid, location and quantitative assessment of valve calcification, valve planimetry.
- Measurement of the aortic sinus diameter, sinotubular junction, ascending and descending aorta (significant aneurysmal dilatation is a contraindication; the presence of extensive atherosclerotic plaque is likely associated with complications including stroke).

- Iliofemoral arteries evaluation: size of the iliofemoral arteries, vessel calcifications and tortuosity (to avoid vascular complications such as access site hemorrhage/hematoma or central embolization).

Transesophageal Echocardiography

- TOE indications: (1) valve disease; (2) cardiac source of embolism (PFO); (3) aortic disease; (4) endocarditis; (5) cardiac masses; (6) congenital heart disease; (7) prior cardioversion; (8) intraoperative monitoring of valve procedures; (9) interventional procedures.
- Blind spot: Distal part of the ascending aorta and proximal aortic arch for the interposition of the trachea and right bronchus. Aortic dissection can be missed.

Transplantation, Cardiac

- Two types: (1) orthotopic, the patient's heart is removed and replaced with the donor heart; (2) heterotopic, the patient's heart is left in place to support the donor heart.
- Two techniques: (1) biatrial; (2) bicaval.
- Mean postoperative survival: 15 years.
- *CT*: (1) coronary arteries, to assess coronary allograft vasculopathy (concentric narrowing of the lumen for intimal hyperplasia); (2) heart chambers; (3) cardiac function; (4) opportunistic lung infections and malignancies secondary to immunosuppression.
- Beta-blockers are ineffective in transplanted patient to reduce cardiac frequency because the heart is denervated.
- *MR*: (1) graft-versus-host disease detection, diffuse myocardial LE; (2) myocardial ischemia and infarct secondary to coronary allograft vasculopathy; (3) heart chambers; (4) cardiac function.

Transposition of the Great Arteries

- Congenital anomaly in which the aorta arises from the right ventricle and the pulmonary artery from the left ventricle.
- The commonest cyanotic cardiac disease presenting in newborns.
- Palliative Rashkind procedure for newborns: transcatheter atrial septostomy.
- Surgical correction: arterial switch (LeCompte/French maneuver) or atrial switch (Mustard or Senning procedure).
- After arterial switch look for branch pulmonary artery stenosis (vessel caliber, poststenotic dilatation, and flow acceleration/reduction).
- After atrial switch SVC and IVC baffles redirect systemic venous return to the subpulmonary left heart; baffles might be obstructed or leaky.
- *MR*: (1) cardiac function (in atrial switch the systemic RV function might be compromised with tricuspid regurgitation, especially after years from the correction); (2) do SVC and IVC flows and look at the azygos caliber and flow direction; (3) perform 3D SSFP navigator sequence to visualize origin and proximal course of reimplanted coronaries (exclude gross kinking/coronary obstruction); (4) LE assessment.

Tricuspid Atresia

- No direct communication between the right atrium and the right ventricle.
- Two types: (1) absence of right atrioventricular connection with an areolar sulcus tissue (fatty tissue) occupying the gap; (2) presence of an atretic valve (less common).

Tricuspid Valve

- Three leaflets: septal, inferior, and anterosuperior (occasionally are two or four leaflets).
- Apically displaced and usually thinner than the mitral valve.
- The valve orifice is larger than the mitral orifice. Normal tricuspid valve between 3 and 5 cm^2.

Tricuspid Valve Regurgitation

- Trivial regurgitation is a common finding in normal subjects.
- Causes: (1) right ventricular failure; (2) rheumatic heart disease; (3) infective endocarditis; (4) congenital; (5) carcinoid; (6) rheumatoid arthritis; (7) trauma; (8) prolapse.
- Predictor bad outcome in ToF for arrhythmias.
- *CT*: (1) Evaluate leaflet morphology and thickening; (2) assess for incomplete leaflet coaptation in the end-systolic phase; (3) evaluate the presence of reflux of contrast material into the IVC and hepatic veins during the first pass of contrast material.
- *MR*: (1) The jet is usually visualized in LA view; sometimes the jet is difficult to visualize because of turbulence; use PC in LA view. (2) A set of transaxial images on the right ventricle provides additional informations, particularly for abnormal leaflet morphology such as in Ebstein's anomaly. (3) SA cine view in systole, positioned through the tricuspid valve tips, permits to visualize the regurgitant orifice; through-plane PC at the same plane may give clearer delineation of flow through the orifice and permits to measure the diameter of the regurgitant orifice area; the regurgitant orifice is often noncircular.
- Quantitative flow measurements:
  - Quantification can be achieved using pulmonary flow measurement, combined with RV stroke volume to calculate the

Table 1 Tricuspid valve regurgitation severity

Tricuspid valve regurgitation		
Degree	Regurgitation fraction (%)	Orifice diameter (ml)
Mild	≤30	<2
Moderate	31–50	2–7
Severe	>50	>7

regurgitant volume (RV stroke volume – pulmonary forward flow) and the regurgitant fraction (TR/RV stroke volume × 100 %).
- Quantification can be also achieved using the difference in ventricular stroke volumes if only a single valve leak is present.

Tricuspid Valve Stenosis

- Isolated form is uncommon.
- Causes: (1) rheumatic heart disease (almost always); (2) congenital tricuspid atresia; (3) right atrial tumors; (4) carcinoid syndrome; (5) obstruction to right ventricular inflow (endomyocardial fibrosis, tricuspid valve vegetations, pacemaker lead, extracardiac tumors, Ebstein's anomaly); (6) fusion and shortening of the chordae tendineae and the leaflets at their edges, determining a diaphragm with a fixed central aperture.
- *CT/MR*: (1) Valve planimetry; (2) evaluate leaflet morphology and thickening; (3) assess for cusp non-apposition in the end-systolic phase.
- Quantitative flow measurements:
  - Evaluate early and late peak velocities.
  - Calculate mean transvalvular gradient.

Table 2 Tricuspid valve stenosis severity

Tricuspid valve stenosis	
Degree	Valve area (cm^2)
Mild	>7
Moderate	1–7
Severe	<7

Troponin

- Cardiac troponin: I and T.
- Marker of myocardial damage.
- Definition of myocardial necrosis for MI: maximal concentration of cTn exceeding the 99th percentile of values (>0.01 ng/mL) for a reference control group on at least one occasion during the first 24 h after the clinical event.
- Diagnostic cutoff: high-sensitivity cTn >0.04 ng/mL.
- In case of diagnostic incertitude for MI: look at cTn kinetic (serial troponin testing: 1 h after pain onset, 6–9 h and 12–24 h).
- Other causes of elevated plasma cardiac troponin other than acute coronary syndrome: (1) cardiac (myocarditis/pericarditis, aortic dissection, acute/chronic heart failure, HCM, post-PCI, cardiac surgery, cardiac contusion, aortic valve disease); (2) noncardiac (pulmonary embolism, pulmonary hypertension, renal failure, stroke, amyloidosis, sepsis, extensive burn, cardiotoxic drug).

Truncus Arteriosus

- Congenital disease in which aorta and pulmonary artery arise from a common trunk with a single truncal valve associated with a large VSD.
- Associated lesions: (1) interrupted aortic arch; (2) aortic coarctation, (3) ASD.

- Surgery in the 1 month of life to create separate outflow tracts.
- Correction with interposition of RV to Pulmonary arteries conduit.
- Complications: stenosis of the outflow tracts or valvular regurgitation.

Tumors, Cardiac

- Incidence: 0.1–0.3 %.
- Benign tumors more common than malignant.
- Metastases are the commonest cardiac malignancy.
- *MR*: (1) lesion detection and infiltration; (2) mass motion; (3) T_1 and T_2 signal; (4) STIR hyperintensity, suggestive of malignancy; (5) perfusional study, rapid contrast washout suggestive of malignancy; (6) early enhancement, thrombi detection; (7) LE study, area of necrosis and contrast sequestration; (8) pleural effusion, suggestive of malignancy.
- *CT*: (1) lesion detection and infiltration; (2) mass motion; (3) thrombus detection; (4) tumor contrast enhancement; (5) lung metastasis or primitive lesion.

Turner's Syndrome

- Genetic disorder resulting from the absence of one X chromosome.
- *Major characteristics*: (1) aortic coarctation; (2) absence of secondary sexual characteristics; (3) short stature; (4) lymphedema.

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U

Univentricular Heart

- Congenital heart disease.
- Three variants: (1) dominant LV with rudimentary RV; (2) dominant RV with rudimentary LV; (3) solitary ventricle.
- Univentricular heart can have three main atrioventricular valve configurations: (1) absent right AV valve, with no connection between RA and RV; (2) absent left AV valve, with no connection between LA and LV; (3) double inlet, with both atria connected to the main ventricle.

Uremic Pericarditis

- Hemorrhagic inflammation produced by uremia.
- May lead to tamponade and constriction.

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V

Valvular Cardiomyopathy

- Patients with long-standing valvular disease develop a cardiomyopathy which usually improves after disease correction.

Valvular Tumors

- Very rare tumors.
- Papillary fibroelastoma is the most common primary valvular tumor and frequently occurs on aortic valve cusps.
- Myxoma and Hamartoma are less common.
- Depending on their locations, valvular tumors can develop fibrin clots, which can subsequently embolize into the systemic or pulmonary circulation.
- *CT*/*MR*: can detect small tumors and assess their motion during the cardiac cycle.

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Valvular Vegetations

- Caused by endocarditis.
- Factors predisposing to endocarditis include intravenous drug use, poor dental hygiene, long-term hemodialysis, diabetes mellitus, mitral valve prolapse syndrome, and prosthetic valves.
- The vegetations follow the motion of the valvular cusp to which they are attached.
- Frequently the posterior leaflet of the mitral valve is involved.
- See also *Endocarditis*.

Vascular Remodeling

- Positive or negative.
- To assess the extent and direction of remodeling in individual lesions, it is necessary to compare vessel size at the lesion site to an adjacent reference site that contains minimal disease.
- Positive and negative remodeling is defined as larger or smaller external vessel area at the lesion site than at an adjacent reference site.

Vascular Ring

- Abnormal embryological development of one or more thoracic arteries.
- Vascular rings lead to variable respiratory symptoms and/or feeding difficulties because a complete or partial ring of vascular tissue surrounds and compresses the trachea, the bronchi, and the esophagus.

- Tracheal stenosis is significant when >50 %.
- *CT*: offers better comprehension of anatomic relationships between airway and anomalous vessels often with no need for sedation.
- *MR*: (1) Always requires general anesthetic in children; (2) always include in the MR protocol orthogonal breath-hold black-blood sequence and 3D CEMRA.
- Surgical correction, intended as resection and/or reimplantation of anomalous vessel, often improves respiratory symptoms. These are predominantly consequences of long-standing airway compression, resulting in tracheobronchomalacia.

Velocity-Encoded Gradient

- To obtain accurate flow measurement, set the right VENC.
- VENC should be just above the flow peak velocity.
- If VENC < peak velocity: aliasing artifact.
- Start using standard VENC value for each vessel and increase of 10 by 10 until aliasing artifact disappears.
- Normal aortic valve VENC: 150.
- Normal pulmonary arteries and valve VENC: 70.
- Normal superior and inferior vena cava VENC: 30–40.

Ventricular Chambers Identification

- Left ventricle: no moderator band, smooth (less trabeculation), mitral valve.
- Right ventricle: more trabeculated with apical moderator band, muscular RVOT, tricuspid valve.

Ventricular Septal Defect

- Isolated or in combination with other congenital heart disease.
- Three types: (1) perimembranous (80 %), in the membranous portion of the septum; (2) muscular (5 %), in the muscular septum; (3) subarterial (5 %), under aortic valve.
- Restrictive defect: small VSD (usually less than 1/3 of the aortic valve diameter) with significant gradient and normal RV pressure and pulmonary resistance.
- Nonrestrictive defect: Large VSD (usually >1/2 of the aortic diameter) with LV and RV pressure equalization and increased pulmonary resistance with the onset of Eisenmenger syndrome in long-standing defects. Qp/Qs >2. Surgical or percutaneous correction is required.
- Small VSDs tend to close spontaneously, particularly if apical and muscular.
- Subarterial type can damage arterial leaflets and usually is closed also in case of limited shunt.
- Small muscular VSD sometimes can be visualized only with echocardiography using Valsalva maneuver.
- See also *Qp*/*Qs* and *Eisenmenger Syndrome*.

Ventricular Systolic Function

Table 1 Classification of left ventricular systolic function according to EF

LV ejection fraction	
>75 %	Hyperdynamic
55–75 %	Normal
40–54 %	Mildly reduced
30–39 %	Moderately reduced
<30 %	Severely reduced

Table 2 LV and RV volumes and mass

Normal ventricular volumes and mass in adult				
Ventricle	LV		RV	
Gender	Male	Female	Male	Female
EF (%)	57–81	57–81	47–71	53–73
EDV (mL)	102–218	83–187	124–256	78–218
ESV (mL)	18–82	18–66	38–118	20–92
SV (mL)	74–150	57–125	75–151	52–128
Myocardial mass (g)	81–165	42–150	25–57	21–49
EDV index (mL/m^2)	56–108	54–102	66–126	50–118
ESV index (mL/m^2)	9–41	12–36	19–59	12–52
SV index (mL/m^2)	40–72	36–72	41–73	35–71
Myocardial mass index (g/m^2)	45–81	31–79	13–28	13–27

Ventricular Volumes

- Ventricular volumes and mass should be normalized for patient BSA.
- Absolute and indexed value should be included in the report.

Suggested Reading

Dillman JR et al (2011) Common and uncommon vascular rings and slings: a multi-modality review. Pediatr Radiol 41:1440–1454

Hudsmith LE et al (2005) Normal human left and right ventricular and left atrial dimensions using steady state free precession magnetic resonance imaging. J Cardiovasc Magn Reson 7:775–782

Kiefer TL et al (2012) Infective endocarditis: a comprehensive overview. Rev Cardiovasc Med 13:e105–e120

Warnes CA et al (2008) ACC/AHA 2008 guidelines for the management of adults with congenital heart disease. Circulation 118:e714–e833

W

Wall Motion Score Index

- Sum of wall motion scores divided by the number of segmented scored.
- Wall motion score: (1) normokinesis (50 % thickening); (2) hypokinesis; (3) akinesis; (4) dyskinesis.
- Used before and after stress in dobutamine stress MR.

Warfarin Ridge

- Ridge between left atrial appendage and left upper pulmonary artery which can be misinterpreted as thrombus if prominent.
- *Characteristics*: elongated structure in continuity with left atrial wall.

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Waterston Shunt

- Ascending aorta to right pulmonary anastomosis.
- Surgical technique used in pulmonary atresia repair.
- Alternative to subclavian artery to pulmonary artery anastomosis (Blalock–Taussig shunt).
- See also *Pulmonary Atresia*.

Wegener's Granulomatosis

- Vasculitis of small- and medium-size vessels.
- Rare cause of pericarditis and coronary arteritis.

Weil Disease

- Myocarditis due to leptospirosis.
- Coronary arteritis and aortitis can coexist.

Wenckebach's Phenomenon

- Second-degree atrioventricular block characterized by progressive lengthening of the PR interval until a P wave is not conduct.
- See also *Atrioventricular Block*.

Whipple Disease

- Disease caused by Tropheryma whipplei.
- *Characteristics*: (1) myocardial involvement; (2) valve fibrosis with aortic and mitral regurgitation; (3) pulmonary arterial hypertension; (4) coronary artery lesions.

William's Syndrome

- Congenital supravalvular aortic stenosis associated with pulmonary artery stenosis, hypercalcemia, elfin facies, and compartmental anomalies.
- Coronary arteries can dilate with accelerated atherosclerosis.

Window/Level Setting

- Optimization of W/L settings is mandatory to accurately quantify CT coronary plaques.
- A W/L setting of approximately 740 (width) and 220 (center) should be used in the assessment of coronary plaque to obtain reliable quantitative results.

Wolff–Parkinson–White Syndrome

- Abnormal accessory conduction pathway between atria and ventricles.
- Cause of tachycardia.
- *Characteristics*: preexcitation wave (delta wave) and short PR interval.

Suggested Reading

Angeli E et al (2012) Natural and modified history of single-ventricle physiology in adult patients. Eur J Cardiothorac Surg 42:996–1002

Kilner PJ (2011) Imaging congenital heart disease in adults. Br J Radiol 84:S258–S268

X

X, Syndrome

- Angina with sign of decrease myocardial blood flow and normal coronary arteries.
- Myocardial perfusion imaging can be abnormal in 30 % of patients.
- No specific cause. Probably due to microvascular disease.
- See also *Angina*.

Suggested Reading

Herrmann J et al (2012) Coronary microvascular dysfunction in the clinical setting: from mystery to reality. Eur Heart J 33:2771–2782

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Y

No lemma

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Z

No lemma

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