



**OBJECTIVES FOR TRAINING IN CARDIOVASCULAR MAGNETIC RESONANCE (CMR)
CARDIOLOGY TRAINING PROGRAM
UNIVERSITY OF CALGARY**

MEDICAL EXPERT:

At the completion of this rotation the resident will:

- (1) be able to describe the common indications for routine CMR studies
- (2) be able to describe the indications for CMR studies in diagnosis and management of common medical conditions and emergencies
- (3) be able to list the different CMR imaging techniques i.e. T1- and T2 – weighted sequences, SSFP-cine, early and late enhancement and describe the information provided by each technique
- (4) be able to identify standard CMR imaging orientations and techniques
- (5) when given a diagram of the left ventricle, the resident will be able to label the 16 echocardiographic segments and relate them to coronary supply
- (6) be able to provide a qualitative assessment of bi-ventricular contractility using long and short axis cine images
- (7) be able to provide a qualitative and quantitative assessment of common abnormalities (i.e. stenosis/regurgitation) of all 4 cardiac valves
- (8) be able to reproduce and explain the principles of the following quantitative assessments of valve function: planimetry of the aortic, pulmonary and mitral valve, pressure assessment using flow-sensitive sequences; quantification of regurgitation fraction
- (9) be able to assess myocardial viability using late enhancement techniques
- (10) be able to assess stress-inducible myocardial ischemia using adenosine and/or dobutamine
- (11) demonstrate an ability to apply information from CMR study to clinical patient management. The resident identifies the limitations of echo within the context of the clinical problem
- (12) be able to identify the CMR features of common congenital abnormalities i.e. bicuspid aortic valve, secundum atrial septal defect, ventricular septal defect, and Tetralogy of Fallot (repaired)
- (13) maintain a written log of CMR studies carried out and interpreted. A minimum of 50 studies will be required at the completion of all rotations in CMR

COMMUNICATOR:

- (1) demonstrate respect and concern for patients referred for CMR studies
- (2) demonstrate appreciation of issues related to patient confidentiality

COLLABORATOR:

- (1) demonstrate ability to provide both verbal and written report of CMR findings
- (2) demonstrate collegial relationships with technologists and cardiologists in the CMR centre

MANAGER:

- (1) be able to prioritize requests for CMR studies based on patient's clinical problem

SCHOLAR:

- (1) make use of various learning modalities in the CMR centre lab, i.e. teaching from technologists, senior readers, pre-recorded case studies, CD's and journals
- (2) teach more junior learners in the CMR centre
- (3) identify own learning needs and take advantage of available learning resources
- (4) complete a rotation-specific evaluation to provide feedback to preceptors at the completion of the rotation



CMR Training Program



PROFESSIONAL:

- (1) the resident will be punctual for rounds, conferences, and educational events
- (2) the resident will follow through on assigned tasks
- (3) the resident will be respectful when dealing with patients, families, and other professionals

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Objectives “Introduction to CMR”

Duration: 1-week

Interpretation of 10 CMR studies

Lectures and self-study in CMR, 2 hours coursework

Basic aspects of CMR

- Indications, contraindications
- Acquisition approaches

Physics

- Image intensity and contrast
- Patient safety
- Safety of devices in the CMR environment

Procedures / standard

- Tomographic still-frame CMR for morphology using “bright” and/or “dark blood” methods with and/or without a paramagnetic contrast agent
- Cine and other approaches to CMR for assessment of ventricular function
- Late contrast enhancement CMR imaging for myocardial infarction, scar, intra-ventricular thrombus and microvascular obstruction (associated with MI) and viability assessment

Techniques

- Imaging of structure and tissue characterization (T1, T2, spin echo, SSFP and fat suppression)
- Imaging of ventricular function (cine and tagged cine MRI, including SSPFP)
- Volumetric imaging of mass, biventricular volumes, ejection fraction (using cine)
- Imaging of myocardial infarction, scarring, and viability assessment (late enhancement imaging)
- ECG and peripheral pulse gating and triggering including timing of image acquisition within the R-R interval, motion artifacts and their effects on CMR images; respiratory motion suppression (e.g. breath holding and navigators)
- Imaging analysis and post processing tools.

Objectives “Level 1” training (“general training”)

Duration of training: 1-month (minimum)

Interpretation of 50 CMR studies (minimum)

Lectures and self-study in CMR, 10 hours coursework

Basic aspects of CMR

- Specificity, Sensitivity, diagnostic accuracy
- Costs
- Indications, contraindications
- Pitfalls
- Acquisition approaches

Physics

- Image intensity and contrast
- T1 and T2 relaxation
- Contrast agents
- Artifacts
- Patient safety
- Safety of devices in the CMR environment

Procedures / standard

- Tomographic still-frame CMR for morphology using “bright” and/or “dark blood” methods with and/or without a paramagnetic contrast agent
- Cine and other approaches to CMR for assessment of ventricular function
- Late contrast enhancement CMR imaging for myocardial infarction, scar, intra-ventricular thrombus and microvascular obstruction (associated with MI) and viability assessment
- First-pass CMR imaging (with vasodilator infusion) or cine CMR imaging with stress (with inotropic agent) for myocardial perfusion evaluation and ischemia detection.
- Phase-contrast velocity mapping for blood flow quantification for shunt sizing and determination of regurgitation and stenosis.

Techniques

- Imaging of structure and tissue characterization (T1, T2, spin echo, SSFP and fat suppression)
- Imaging of ventricular function (cine and tagged cine MRI, including SSFP)
- Volumetric imaging of mass, biventricular volumes, ejection fraction (using cine)
- Flow imaging (velocity encoded techniques)
- Imaging of myocardial infarction, scarring, and viability assessment (late enhancement imaging)
- Pharmacologic stress testing with evaluation of ventricular function and/or first pass perfusion using a contrast agent
- ECG and peripheral pulse gating and triggering including timing of image acquisition within the R-R interval, motion artifacts and their effects on CMR images; respiratory motion suppression (e.g. breath holding and navigators)
- Imaging analysis and post processing tools.

Objectives “Level 2” training (“specialized training”)

Duration of training: 3-months (minimum)

Interpretation of 150 CMR studies, performing of 50 CMR studies (minimum)

Lectures and self-study in CMR, 30 hours coursework. Written examination

Basic aspects of CMR

- Specificity, Sensitivity, diagnostic accuracy
- Costs
- Indications, contraindications
- Pitfalls
- Acquisition approaches
- Dedicated protocols

Physics

- Image intensity and contrast
- T1 and T2 relaxation
- Measurements of blood flow
- Contrast agents
- Artifacts
- Image formation
- Patient safety, safety of devices in the CMR environment
- Imaging sequences
- Hardware components

Procedures / standard

- Tomographic still-frame CMR for morphology using “bright” and/or “dark blood” methods with and/or without a paramagnetic contrast agent
- Cine and other approaches to CMR for assessment of ventricular function
- Magnetic resonance angiography and Cine CMR of the great vessels, anomalous coronary arteries, and coronary artery bypass grafts
- Late contrast enhancement CMR imaging for myocardial infarction, scar, intra-ventricular thrombus and microvascular obstruction (associated with MI) and viability assessment
- First-pass CMR imaging (with vasodilator infusion) or cine CMR imaging with stress (with inotropic agent) for myocardial perfusion evaluation and ischemia detection.
- Phase-contrast velocity mapping for blood flow quantification for shunt sizing and determination of regurgitation and stenosis.
- MR angiography of central arteries and veins
- Myocardial tagging
- MR angiography of native coronary arteries

Techniques

- Imaging of structure and tissue characterization (T1, T2, spin echo, SSFP and fat suppression)
- Imaging of ventricular function (cine and tagged cine MRI, including SSFP)
- Volumetric imaging of mass, biventricular volumes, ejection fraction (using cine)
- Flow imaging (velocity encoded techniques)
- Imaging of myocardial infarction, scarring, and viability assessment (late enhancement imaging)
- Pharmacologic stress testing with evaluation of ventricular function and/or first pass perfusion using a contrast agent
- MR Angiography
- ECG and peripheral pulse gating and triggering including timing of image acquisition within the R-R interval, motion artifacts and their effects on CMR images; respiratory motion suppression (e.g. breath holding and navigators)

- Imaging analysis and post processing tools.
- Incidental findings suggesting pathology outside of cardiovascular system.

Objectives “Level 3” training (“advanced training”)

Duration of training: 12-months (minimum)

Interpretation of 300 CMR studies, performing of 100 CMR studies (minimum)

Lectures and self-study in CMR, 120 hours coursework. Written examination

Completed research project in CMR

Basic aspects of CMR

- Specificity, Sensitivity, diagnostic accuracy
- Costs
- Indications, contraindications
- Pitfalls
- Acquisition approaches
- Dedicated protocols

Physics

- Image intensity and contrast
- T1 and T2 relaxation
- Measurements of blood flow
- Contrast agents
- Artifacts
- Image formation
- Patient safety, safety of devices in the CMR environment
- Imaging sequences
- Hardware components

Procedures / standard

- Tomographic still-frame CMR for morphology using “bright” and/or “dark blood” methods with and/or without a paramagnetic contrast agent
- Cine and other approaches to CMR for assessment of ventricular function
- Magnetic resonance angiography and Cine CMR of the great vessels, anomalous coronary arteries, and coronary artery bypass grafts
- Late contrast enhancement CMR imaging for myocardial infarction, scar, intra-ventricular thrombus and microvascular obstruction (associated with MI) and viability assessment
- First-pass CMR imaging (with vasodilator infusion) or cine CMR imaging with stress (with inotropic agent) for myocardial perfusion evaluation and ischemia detection.
- Phase-contrast velocity mapping for blood flow quantification for shunt sizing and determination of regurgitation and stenosis.
- MR angiography of central arteries and veins
- Myocardial tagging
- MR angiography of native coronary arteries

Techniques

- Imaging of structure and tissue characterization (T1, T2, spin echo, SSFP and fat suppression)
- Imaging of ventricular function (cine and tagged cine MRI, including SSPFP)
- Volumetric imaging of mass, biventricular volumes, ejection fraction (using cine)
- Flow imaging (velocity encoded techniques)
- Imaging of myocardial infarction, scarring, and viability assessment (late enhancement imaging)
- Pharmacologic stress testing with evaluation of ventricular function and/or first pass perfusion using a contrast agent
- MR Angiography
- ECG and peripheral pulse gating and triggering including timing of image acquisition within the R-R interval, motion artifacts and their effects on CMR images; respiratory motion suppression (e.g. breath holding and navigators)
- Imaging analysis and post processing tools.
- Incidental findings suggesting pathology outside of cardiovascular system.
- Essentials of data collection, capturing of digital data, maintenance of accurate databases and records
- Signal processing
- Obtaining of quantitative data
- Basic principles of spectroscopy

Participation in research

- Identification of a suitable research topic
- Detailed description of the research protocol
- Statistical analysis, sample size calculation
- Participation in patient screening, inclusion and scanning
- Scanning of phantoms and / or volunteers, if applicable
- Presentation of results during research rounds at the Stephenson CMR centre
- Preparation of manuscript