CARDIAC IMAGING TECHNIQUES

LEARNING OBJECTIVES

• By the end of the lecture the student should be able to know:
  • Tests for cardiac imaging
  • ETT
  • MRI
  • CT scan
  • ECHO, Stress & Trans-esophageal echo
  • ECG

X-RAY CHEST

• This is useful for determining the size and shape of the heart, and the state of the pulmonary blood vessels and lung fields.

Points to consider

• Abdominal and cardiac situs
• Cardiac size and contour
• Mediastinum-pulmonary artery, aortic arch
• Pulmonary vascularity-normal, oligemic, plethoric
• Skeletal or other abnormalities
DILATION OF INDIVIDUAL CARDIAC CHAMBERS

- Left atrial dilation results in
- prominence of the left atrial appendage, creating the appearance of a straight left heart border,
- a double cardiac shadow to right of the sternum, and
- widening of the angle of the carina (bifurcation of the trachea) as the left main bronchus is pushed upwards.

LUNG FIELDS ON THE CHEST X-RAY

- May show congestion and oedema in patients with heart failure and an increase in pulmonary blood flow (‘pulmonary plethora’) in those with left-to-right shunt. Pleural effusions may also occur in heart failure.
ELECTROCARDIGRAMS

The ECG is used to assess
- cardiac rhythm and conduction.
- Gives information for ischemic heart disease.

ECG LEADS:

There are 12 standard ECG Leads. The reason for recording and analyzing more than a single ECG lead is that different parts of the heart can be "seen" better from different angles (provided by different leads). Each ECG lead provides a different view of the same cardiac activity. The 12 standard ECG leads are divided in limb leads, called --- I, II, III, AVR, AVL
and AVF --- and chest leads called ---V1, V2, V3, V4, V5, V6.

LIMB LEADS

- Lead I  Right Arm (-ve) to Left Arm (+ve)
- Lead II Right Arm (-ve) to Left Leg (+ve)
- Lead III Left Arm (-ve) to Left Leg (+ve)
- aVR   Right Arm (+ve) to Left Arm & Left Leg (-ve)
- aVL   Left Arm (+ve) to Left Leg & Right Arm (-ve)
- aVF   Left Leg (+ve) to Left Arm & Right Arm (-ve)
ECG Leads:

**Chest Leads:**

- **V1** 4th intercostal space just to the right of the sternum.
- **V2** 4th intercostal space just to the left of the sternum.
- **V3** Half way between V2 & V4.
- **V4** 5th intercostal space in the left mid-clavicular line.
- **V5** On same horizontal as V4 in anterior axillary line.
- **V6** On same horizontal as V4 in mid-axillary line.

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### ECG Leads: How to read a 12-lead ECG: examination sequence

<table>
<thead>
<tr>
<th>Rhythm strip</th>
<th>To determine heart rate and rhythm (lead II)</th>
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<tbody>
<tr>
<td>ECG axis</td>
<td>Normal if QRS complexes are in leads I and II</td>
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<tr>
<td>P-wave shape</td>
<td>Tall P waves denote right atrial enlargement.</td>
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<tr>
<td>PR interval</td>
<td>Normal = 0.12–0.20 sec. Prolongation denotes</td>
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<tr>
<td></td>
<td>atrial fibrillation. A short PR interval</td>
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<tr>
<td></td>
<td>occurs in Wolf–Parkinson–White syndrome (p. 565)</td>
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<tr>
<td>QRS duration</td>
<td>If P = 0.12 sec then ventricular conduction is</td>
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<tr>
<td></td>
<td>abnormal (left or right bundle branch block).</td>
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<tr>
<td>QRS amplitude</td>
<td>Large QRS complexes are seen in young</td>
</tr>
<tr>
<td></td>
<td>patients and in patients with left ventricular</td>
</tr>
<tr>
<td></td>
<td>hypertrophy.</td>
</tr>
<tr>
<td>Q waves</td>
<td>May signify previous myocardial infarction (MI).</td>
</tr>
<tr>
<td>ST segment</td>
<td>ST elevation may signify MI, pericarditis or</td>
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<tr>
<td></td>
<td>left ventricular aneurysm; ST depression may</td>
</tr>
<tr>
<td></td>
<td>signify myocardial ischaemia or infarction.</td>
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<tr>
<td>T waves</td>
<td>T-wave inversion has many causes, including</td>
</tr>
<tr>
<td></td>
<td>myocardial ischaemia or infarction, and electrolyte</td>
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<tr>
<td></td>
<td>disturbances.</td>
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<tr>
<td>QT interval</td>
<td>Normal = 0.42 sec. QT prolongation may occur</td>
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<tr>
<td></td>
<td>with congenital long QT syndrome, hypokalaemia,</td>
</tr>
<tr>
<td></td>
<td>and some drugs (see Box 16.35, p. 568).</td>
</tr>
</tbody>
</table>

### ECG conventions

- Depolarisation towards electrode: positive deflection
- Depolarisation away from electrode: negative deflection
- Sensitivity: 10 mm = 1 mV
- Paper speed: 25 mm per second
- Each large (5 mm) square = 0.2 s
- Each small (1 mm) square = 0.04 s
- Heart rate = 1,500/RR interval (mm) (e.g. 900 + number of large squares between beats)
EXERCISE (STRESS) ECG

- Exercise electrocardiography is used to detect myocardial ischemia during physical stress and is helpful in the diagnosis of coronary artery disease. A 12-lead ECG is recorded during exercise on a treadmill or bicycle ergometer.

Contraindications
Stress testing is contraindicated in the presence of acute coronary syndrome, decompensated heart failure and severe hypertension.

EXERCISE TOLERANCE TEST
Indications
- Coronary artery disease
- Gauge exercise capacity in heart failure patients
- To diagnose heart-related causes of symptoms such as chest pain, shortness of breath or lightheadedness.
- Predict risk of dangerous heart-related conditions such as a heart attack.

EXERCISE TOLERANCE TEST
High Risk Findings
- Low threshold ischemia (i.e. within stage 1 or 2 of the Bruce protocol)
- Fall in BP on exercise
- Widespread, marked or prolonged ischemic ECG changes
- Exercise-induced arrhythmia

RESULTS

- A test is ‘positive’ if anginal pain occurs, BP falls or fails to increase, or if there are ST segment shifts of > 1mm. Exercise testing is useful in confirming the diagnosis in patients with suspected angina, and in such patients has good sensitivity and specificity.
- False negative results can occur in patients with coronary artery disease, and some patients with a positive test will not have coronary disease (false positive).
Echocardiography uses the technology to bounce sound waves off the heart's chambers and valves, creating still and moving images of the heart.

**ECHOCARDIOGRAPHY**

**TYPES**

- Color-Flow Doppler Echocardiograms
- Signal averaged ECG
- Stress Echocardiogram (exercise and pharmacological)
- Transesophageal Echocardiogram

**ECHOCARDIOGRAPHY**

- Depends on the doppler principal that sound Waves reflected from moving objects, such as intracardiac red blood cells, undergo a frequency shift.
- The speed of and direction of the red cells and thus of blood, can be detected in the heart chambers and great vessels.
- The greater the frequency of shift, the faster the blood is moving.

**ECHOCARDIOGRAPHY**

- The derived information can be presented either as a plot of blood velocity against time for a particular point in the heart or as a color overlay on a two-dimensional real time Echo picture.
COMMON INDICATIONS OF ECHOCARDIOGRAPHY

- Assessment of LV function.
- Diagnosis and Quantification of severity of the valve disease.
- Identification of vegetations in endocarditis.
- Identification of structural heart disease in AF, CMP or CHD.
- Detection of Pericardial effusion.
- Identification of intracardiac thrombus.

TRANSEOPHAGEAL ECHOCARDIOGRAPHY

- Uses an endoscope like ultrasound probe which is passed into the esophagus under light sedation and positioned immediately behind the left atrium. This produces high resolution images especially for
  - prosthetic mitral valve dysfunction,
  - CHD like ASD, Aortic dissection, IE (vegetation), systemic embolism.

STRESS ECHOCARDIOGRAPHY

- A 2-Dimensional Echo cardiography is performed before and after infusion of a moderate to high dose of an inotropic such as dobutamine.
- Myocardial segments with poor perfusion become ischemic and contact poorly under stress, showing as a wall motion abnormality on the scan.

STRESS ECHOCARDIOGRAPHY

- Used to examine Myocardial Viability, in patient with impaired LV function.
- Assess viability in hybernating myocardium for fitness for bypass surgery or percutaneous coronary intervention.
- Performed in patient with suspected pt for IHD who are unsuitable for excercise stress test or pre existing LBBB.
COMPUTED TOMOGRAPHIC (CT) IMAGING

- An imaging technique that produces detailed, cross-sectional pictures ("slices") of Cardiac Chambers, Great vessels, pericardium, and mediastinal structures and masses.

- Can acquire up to 320 Slice per rotation allowing very high resolution imaging using a timed injection of x-ray contrast taken from different angles.

- Contrast Scan using a timed injection of X-ray contrast produces a clear images of Aortic dissection and of pulmonary artery and its branches in Pulmonary embolism.

CAT SCANS

- Multi-detector scanning shows imaging of the epicardial coronary arteries with spatial resolution approaching that of conventional coronary arteriography.

- Can be used for the initial elective assessment of suspected CAD & Graft Patency as well as coronary artery calcification.
AMBULATORY ECG

- Continuous (ambulatory) ECG recordings can be obtained using a portable digital recorder.
- These devices usually provide limb lead ECG recordings only, and can record for between 1 and 7 days.
- Ambulatory ECG recording is principally used in the investigation of patients with suspected arrhythmia, such as those with intermittent palpitation, dizziness or syncope

HOLTER MONITORING

USES

- to detect abnormal **heart rhythms** (arrhythmias) as well as cardiac ischemia
- to detect transient and short cardiac arrhythmias that might not be present during in-office EKG monitoring.
- to monitor pacemakers or evaluate how well medications are working especially anti-arrhythmics

MAGNETIC RESONANCE IMAGING

- An imaging technique that produces detailed, accurate, cross-sectional pictures ("slices") of internal organs and body parts.
- But it doesn’t use ionizing radiation and has no known biological risks.

WHY MRI?

- Non invasive
- Provides much greater **contrast** between the different soft tissues of the body than CT
- considered generally safer than contrast-enhanced x-ray tests in unstable patients
MAGNETIC RESONANCE IMAGING USE IN CARDIOLOGY

- Aortic disease
- Blockages within the coronary arteries (which supply oxygen-rich blood to the heart)
- A weakened heart muscle (cardiomyopathy)
- The severity of a heart attack
- Heart valve disease
- Disease in the arteries outside the heart, or peripheral arterial disease
- Heart defects present at birth (congenital)
- To assess patients’ progress after a heart attack
- To evaluate blockages in the coronary arteries (which could rupture and cause a heart attack)
- To detect an atrial myxoma (heart tumor)

BLOOD POOL IMAGING

- The isotope is injected intravenously and mixes with the circulating blood.
- A gamma camera detects the amount of isotope-emitting blood in the heart at different phases of the cardiac cycle, & the size and ‘shape’ of the cardiac chambers, by linking the gamma camera to the ECG information can be collected over multiple cardiac cycles, allowing ‘gating’ of the systolic and diastolic phases of the cardiac cycle.
- More sophisticated quantitative information is obtained with positron emission tomography (PET), which can be used to assess myocardial metabolism

MYOCARDIAL PERFUSION IMAGING

- This technique involves obtaining scintiscans of the myocardium at rest and during stress after the administration of an intravenous radioactive isotope such as technetium tetrofosmin
NUCLEAR CARDIOLOGY TEST

- Produce images of the heart at work (during exercise) and at rest.
- Reveal problems in heart muscle and blood vessels, especially when the images of the heart at work and at rest are compared.

PHARMACOLOGIC STRESS TESTS
- Thallium
- Dobutamine
- Persantine

TYPES
- Myocardial Perfusion Scans
- Pharmacologic Stress Tests
- Technetium-99m gated SPECT imaging
- Ventricular Function Studies
- Peripheral Vascular Studies
- Tilt table testing

MYOCARDIAL PERFUSION SCANS
- common test is done in two parts
- first part shows the heart during normal functioning, called "rest."
- During the second part, called "stress," the coronary arteries are dilated through exercise. You may walk on a treadmill or ride a stationary bicycle.

USES
- Identify areas of the heart muscle that have an inadequate blood supply
- Quantify the extent of the heart muscle with a limited blood flow
- Provide information about the heart's pumping function
- Ascertain the amount of scarring from a heart attack
- Evaluate the success of coronary bypass surgery or angioplasty
NUCLEAR CARDIOLOGY TEST

VENTRICULAR FUNCTION STUDIES

Two types of tests
- MUGA (Multi-Gated Acquisition) study (also known as Equilibrium Gated Blood Pool Study)
- Angiography First Pass Study

ELECTROPHYSIOLOGY

- The term “electrophysiology study” or “EP study” applies to any procedure that requires the insertion of an electrode catheter into the heart.

Indications
- Heart rhythm disorders.
- Patient at a risk of sudden cardiac death.
- Evaluate the effectiveness of certain medications.
- Predict the risk of a future cardiac event.
- Assess the need for an implantable device (pacemakers) or treatment procedures

-------------------------------------------THE END------------------------------------------