

THE TAMIL NADU Dr. M.G.R. MEDICAL UNIVERSITY

69, ANNA SALAI, GUINDY, CHENNAI - 600 032.



SYLLABUS

OF

M.Sc. CARDIAC RHYTHM MANAGEMENT & ELECTROPHYSIOLOGY

ACADEMIC YEAR 2024 – 2025 SESSION ONWARDS

Master of Science in Cardiac Rhythm Management and Electrophysiology

Educational Methodology: Learning occurs by attending didactic lectures, as part of regular work, from co-workers and senior faculty, through training offered in the workplace, through reading or other forms of self-study using material available through work, using materials obtained through professional associations.

Working days in the academic year: Each academic year shall consist of not less than 270 working days.

Attendance: 85% of attendance (physical presence) is mandatory in both theory and practical separately in each subject before attending the examination. Medical leave or other types of sanctioned leave will not be counted as physical presence. Attendance will be counted from the date of commencement of the session to the last day of the final examination in each subject.

Condonation for Lack of attendance: There shall be no condonation for lack of attendance

Vacation: There is no vacation

Whether the same Course is already i

n existence in any other State within India and / or outside India:Currently there is no 2-yearMSc in Cardiac Electrophysiology in India, to the best of our knowledge. However, MMM offers some advanced EP exposure to cardiac technicians interested in improving their knowledge in the field. There are Cardiac Electrophysiology Technologist courses available in the UK and USA.

Internal Assessment:

The internal assessment should consist of the following points for evaluation: -

- i. Theory
- ii. Practical

a) A minimum of three written examinations shall be conducted in each subject during a year and the average marks of the three performances shall be taken into consideration for the award of Internal Assessment marks.

Marks qualifying for pass:

50% of marks in the University Theory Examinations

50% of marks in the Practical with Viva

50% of marks in aggregate in Theory, IA and oral taken together

Revaluation / Retotalling of answer papers: This is not permitted.

Teaching responsibilities: The MSc candidates should take classes for B.Sc Cardiac Technology students on a regular basis

Paper Presentation: They are expected to attend at least one cardiology conference during the tenure and present papers for the same

University Examination: University examination will be conducted at the end of every academic year. A candidate who satisfies the requirement of attendance and internal assessment marks, as stipulated by the university shall be eligible to appear for the university examination.

Scheme of Examination:**First year:**

S.No.	Subject title	Internal Assessment		Theory	
		Max.	Min.	Max.	Min.
1	Cardiac Anatomy in relevance to conduction system and Cardiac pathology in relation to myocardial scar	50	25	100	50
2	Cardiac Physiology in relevance to conduction system and Radiation protection with health Physics and Microbiology in relation to sterilization and disinfection	50	25	100	50
3	Cardiac Pharmacology in relevance to antiarrhythmics and Cardiac genetics	50	25	100	50

4	ECG and Cardiopulmonary resuscitation	50	25	100	50
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Second year:

S.No.	Subject title	Internal Assessment		Theory	
		Max.	Min.	Max.	Min.
1	Cardiac arrhythmia investigation modalities	50	25	100	50
2	Cardiac device therapy	50	25	100	50
3	Cardiac arrhythmias, Manoeuvres in the EP lab	50	25	100	50

Theory Examination Pattern:

Duration: 3 hours

10 questions x 10 marks each =100 Marks

	Max.	Min
Project	100	50
Viva/Practical	100	50
Internal Assessment	50	25

Logbook: Each student should maintain a log book and record the procedures they do / observe. This will include the seminars that they presented, and conferences attended. The same will have to be countersigned by their supervisor. It must be assessed by the HOD and submitted at the time of discussion of project in the practical examination.

Project work: Each student shall work on a project under a guide in the department (recommended by the Head of the Department) and submit the project work to the Principal through the HOD, at least 3 months before completion of the course / second year examination. Project should be in a bound volume of a minimum of 30 – 50 pages, typed in double line spacing and on one side only.

Research activities:The candidate must maintain a record of research activities done by him/her and keeps a record of the same. (To be submitted to the Principal before Part II examination).

Program Outcomes:

1. Thorough knowledge of the subject
2. Effective communication skills
3. Ethical practice
4. Leadership quality and teamwork
5. Problem analysis and solving skills
6. Knowledge on research methodology
7. Teaching skills
8. Specialization in the subject
 - a. Technical expert in cardiac device (pacemaker, ICD, CRT) analysis programming and follow up
 - b. Technical expert in supporting procedures in the EP lab including 3D mapping
9. Employability in various sectors

Knowledge and Skills to be acquired by students on completion of the course:

First year:

1. Core knowledge in cardiac anatomy (with emphasis on cardiac conduction system)
2. Core knowledge in cardiac physiology (with emphasis on cardiac electrophysiology)
3. Core knowledge in cardiac pharmacology (with emphasis on drugs used to treat arrhythmias)
4. Core knowledge in cardiac pathology (with emphasis on cardiomyopathies and degenerative conditions resulting in conduction system disease)
5. Knowledge of sterility in Cathlab
6. Knowledge in reading the basics of ECG
7. Knowledge in relevant radiation physics, biophysics of radiofrequency ablation and application
8. Competency in cardiopulmonary resuscitation
9. Knowledge in cardioversion and defibrillators
10. Knowledge in analyzing HOLTER traces
11. Evaluating patients in the outpatient department
12. Presenting a seminar on an EP topic once a month

13. Maintaining a logbook on all cases assisted

Second year:

1. Knowledge in doing cardiac device interrogation
2. Knowledge in interpreting cardiac device traces [Pacemaker, ICD and CRT]
3. Knowledge in care of patients with CIED
4. Knowledge in supporting an EP study and Radiofrequency ablation
5. Knowledge in supporting a complex 3D mapping case
6. Knowledge in analyzing an EP trace
7. Knowledge in connecting a remote monitoring device
8. Supervising the BSc trainee posted in the Cardiac EP Unit

Syllabus

The curriculum of the M.Sc. Cardiac Rhythm Management and Electrophysiology students will comprise different core areas in which they need to acquire knowledge. They will need to be proficient in the objectives listed under each area.

First year subjects:

Paper 1:

1. Anatomy:

Normal and abnormal anatomy of the conduction system, location of HIS bundle, Anatomy of the coronary sinus, left atrium, appendage and pulmonary veins, right atrium, cavotricuspid isthmus, CTI dependent flutter circuit, papillary muscles, coronary cusps, subclavian and axillary veins, moderator band, outflow tracts, phrenic nerve, pericardium, transverse sinus, oblique sinus

2. Pathology:

Myocardial scar post infarction, dilated atria post mitral stenosis or congenital heart disease, tetralogy of fallot, transposition of great vessels, dilated cardiomyopathy, hypertrophic cardiomyopathy

Paper 2:

1. Physiology:

The cardiac action potential, the physiology of the sinus and AV node, Conduction velocities along the conduction system, basic mechanisms of rhythm disorders: reentry, automaticity,

triggered activity, basic mechanisms of syncope, effects of increased vagal tone on the heart, long QT and torsade.

2. **Radiation Protection and Health Physics:**

A. Basic concepts: 5hrs

Basic concepts of power, work, force, energy - electromagnetic waves - Units and measurements - temperature and heat-Atomic structure- Nucleus - Atomic Number, Mass Number.

B. Electromagnetism: 5hrs

Electric charges-electric induction - electric potential-capacitance and capacitors. electrical energy and power - unit of current-resistance and Ohm's law - sources of electrical energy –EMF- Electro-magnetic induction, laws of mutual induction and self induction- transformers -heat losses in transformer-earthing-high tension cables.

C. X-ray Production: 10 hours

Discovery – Production – Properties of X-rays – Characteristic and continuous spectra –X-ray tube – stationary anode and Rotating anode xray tube –Rating of tubes – safety devices in X-ray tubes – cooling of X-ray tubes –faults in X-ray tubes -Modern xray tubes – generators principles in Radiography/fluoroscopy-high voltage transformers – High voltage circuits – Half-wave and full-wave rectifiers –Three phase apparatus – high frequency generators-Current and Voltage stabilizers – Measuring instruments – measurement of kV and mA

D. Interaction of X-and rays with human body: 10hrs

Bremmsrahlung-characteristic xray- Compton-pair production-photon disintegration- scatter- X-Ray transmission through medium-linear and mass attenuation coefficients. HVT - TVT -Interaction of X rays in body-fat-soft-tissue-bone-contrast medium.- importance of different types of interactions in imaging- kedge-influence of kedge in contrast media- Prime factors (kVp, mAs and SID/SFD), influence of prime factors on image quality, selection criteria of prime factors for different types of imaging, different type of projection patient dose vs Image quality (CNR, SNR etc)

Factors influencing scatter radiation, objectives of scatter reduction, contrast reduction factor, scatter reduction methods; **beam restrictors** (diaphragms, cones/cylinders & collimators).

Grids (grid function, different types of stationary grids, grid performance evaluation parameters, moving grids, artifacts caused by grids, grid selection criteria), air gap technique. **Filtration:** Inherent and added filters, purpose of added filters, beryllium filters, filters used for shaping X-ray spectrum (K-edge filters: holmium, gadolinium, molybdenum)

E. Fluoroscopy and Angiography: 15hrs

Introduction-historical background of fluoroscopy-Fluoroscopic equipment- Image intensifier–working principle- cine fluorography- optical coupling –cameras:vidicon, CCD, CMOS - Automatic brightness control- over and under couch tubes safety features. Flat panel fluoroscopy systems -

artifacts causes and remedy. Angiography and DSA: Cardiac angiography principles-image formation-image reconstruction-basic and advanced options in angiographic image reconstruction-DICOM- radiation dosimetry -DAP-air kerma-peak skin dose. Quality assurance in fluoroscopy.

F. Radiation Safety – 20hrs

Radiation Quantities and Units Radiation- Sources of radiation - natural radioactive sources -cosmic rays-terrestrial radiation - - man made radiation sources. Quality factor - Flux-Fluence-Kerma-Exposure- Absorbed dose- Equivalent Dose-Weighting Factors-Effective Dose - Occupational Exposure Limits - Dose limits to public.

Biological Effects of radiation Ionization, excitation and free radical formation, hydrolysis of water, action of radiation on cell -Chromosomal aberration and its application for the biological dosimetry- Effects of whole body and acute irradiation, dose fractionation, effects of ionizing radiation on each of major organ system including fetus -Somatic effects and hereditary effects-stochastic and deterministic effects-Acute exposure and chronic exposure-LD50 - factors affecting radio-sensitivity.

Radiation Hazard evaluation and control Philosophy of Radiation protection, effects of time, Distance & Shielding. Calculation of Work load, weekly calculated dose to radiation worker & General public Good work practice Cardiology. Planning consideration for cath lab, including Use factor, occupancy factors, and different shielding material.

Radiation protection: Radiation protection of self and patient- Principles of radiation protection, time - distance and shielding, shielding - calculation and radiation survey –ALARApersonnel dosimeters (TLD and film batches)- occupational exposure

Regulatory Bodies & regulatory Requirements: International Commission on Radiation Protection (ICRP) / National Regulatory body (AERB - Atomic Energy Regulatory Board) - Responsibilities, organization, Safety Standard, Codes and Guides, Responsibilities of licenses, registrants & employers and Enforcement of Regulatory requirements.

G. Radiation detection and Measurements: 5hrs

Ionization of gases- Fluorescence and Phosphorescence -Effects on photographic emulsion. Ionization Chambers- free air ionization chamber -film dosimeter –Pocket dosimeter-Radiation survey meter -Calibration of Radiation Monitoring Instruments.

3. Microbiology [Sterilization and Disinfection]:

Techniques of catheter sterilization and disinfection, Autoclave, Ethylene di oxide, Plasma sterilization,

Paper 3:

1. Cardiac Pharmacology:

Antiarrhythmic drugs, Isoprenaline, Sorbitrate in HUTT test, Epinephrine challenge test, Adenosine, Magnesium, Effect of drugs on DFT and pacing threshold, CHADS2 and CHADS_{VaSc} scores, Newer Oral Anticoagulants, Warfarin, pro-arrhythmic potential of Anti arrhythmic medications- including Torsade due to prolonged QT and 1: 1 AV conduction with Class I A and IC medications, drug interactions like between warfarin and amiodarone.

2. Cardiac Genetics:

Clinical presentation, evaluation and management of Channelopathies [Long QT, CPVT, Short QT, Brugada], ARVC, HCM. To discuss the arrhythmias in HCM and ARVD and the indications for ICD in these conditions.

Paper 4:

1. ECG :

Normal ECG, leads, measurements of intervals, axis, chamber enlargement, bundle branch blocks, fascicular blocks, ECG findings in coronary artery disease, congenital heart disease, dyselectrolytemia. ECG diagnosis of brady and tachyarrhythmias, pathway localization, differentiation between the differentials of a broad complex tachycardia.

2. CPR :

CPR technique, steps involved in BLS and ACLS, reasons for sudden cardiac death, Cardioversion and Defibrillation.

Second year subjects:

Paper 1 :

Cardiac Arrhythmia Investigation Modalities:

Noninvasive Investigations: ECG, Signal average ECG, Holter, External loop recorders, Treadmill [in evaluation of conduction disorders, channelopathies, accessory pathway conduction properties], HUTT test and responses. ECHO in relation to cardiac EP [assessment of dyssynchrony, towards diagnosing ARVC,

HCM], cardiac MRI [Including its role in scar burden, sarcoidosis, HCM], PET scan [including its role in sarcoidosis]. Evaluation of a patient with syncope.

Invasive Investigations: Flecainide and Epinephrine challenge tests, esophageal EP study, Internal Loop Recorder [interrogation, indications, settings], Electrophysiologic study

Paper 2 :

Cardiac Device Therapy: Dangerous and non-dangerous AV blocks: AV Wenckebach, Mobitz Type II and complete AV block, Indications for pacing, pacing modes, pacing troubleshooting - loss of capture, over and undersensing on A and V leads, high and low lead impedance, rate response function in pacemakers, Conduction system pacing [left bundle and His bundle pacing], Device infections, To discuss the differential diagnosis and approach to syncope, to discuss the causes and management of SCD, interaction of EMI and devices, loop recorders and their role in arrhythmia detection, CRT mechanism, indications for CRT, Management and indication of ICD, CRT and pacemaker patients who need surgery, To discuss the basics of ICD and CRT troubleshooting including monitoring of the recalled leads, short V-V interval count and impedance trend, Ventricular sense response, Altered Optivol fluid index. Lead extraction and complications.

Paper 3 :

Cardiac arrhythmias, Manoeuvres in the EP lab : cardiac arrhythmias [tachy and brady], pathogenesis of arrhythmias, Brady arrhythmias including sick sinus syndrome, AV block, Assessment of bradyarrhythmias in the EP lab, Normal AH, HV intervals, To discuss the mechanism behind the genesis of tachyarrhythmias - automaticity, reentry, triggered activity, Different arrhythmia ECG, mechanism, intracardiac electrograms including atrial fibrillation, flutter, tachycardia, AVRT, AVNRT, Junctional tachycardia, VT, management of patients at Risk of Ventricular Arrhythmias who have never had arrhythmias. Localization of pathway from ECG, atriofascicular pathways, PJRT. Acute management of tachyarrhythmias. Rate versus rhythm strategy for atrial fibrillation, management of preexcited atrial fibrillation. Broad complex tachycardias including VT, SVT with aberrancy, Antidromic AVRT. Management of VT storm, causes of polymorphic VT, VT in structurally normal heart. Arrhythmias in congenital heart disease. Indications for and limitations of electrophysiologic studies, Basics of intracardiac tracings- the ability to interpret intracardiac recordings such as AH and HV intervals, Biophysics of radiofrequency ablation.

Text Books Recommended

1. Braunwald's Heart Disease : A Textbook of Cardiovascular Medicine
2. Grossman's Cardiac Catheterization, Angiography and Intervention
3. Hurst's The Heart Vol 1 & 2
4. Josephson M. Clinical Cardiac Electrophysiology Techniques and Interpretations. 4th edition. Philadelphia, PA: Lippincott Williams & Wilkins, 2008
5. Clinical cardiac pacing, Defibrillation and Resynchronization Therapy: Ellenbogen, Kenneth
6. ECG made easy: Hampton, John. R
7. Podrid, P, et. al. Podrid's Real-World ECGs: A Master's Approach to the Art and Practice of Clinical ECG Interpretation. vols. 3-6. Minneapolis, MN: Cardiotext Publishing; 2016
8. Primer of ECG : A simple and deductive approach : Misra. K P
9. Leo Schamroth An Introduction to Electrocardiography
10. Echocardiography: Feigenbaum, Harvey
11. Handbook of Exercise Testing : Constant, Jules
12. Curry,T.S.Dowdey,J.E. Murry,R.C,(1990), Christensen's introduction to the Physics of diagnostic radiology, 4th edition, Philadelphia, Lea&Febiger
13. Bushberg,S.T; Seibert,J.A; Leidholt,E.M&Boone,J.M.(1994), The essential Physics of Medical imaging, Baltimore, Williams & Wilkins
14. David J. Dowsett; Patrick A. Kenny; Eugene Johnston R. The Physics of Diagnostic imaging
15. Hendee,W.R.&Ritenour,R.(1993) Medical Imaging Physics, 3rd edition
16. Dendy,P.P.&Heaton,B. Physics for diagnostic radiology, 2nd edition
17. Klein, GJ, Gula, LJ, Leong-Sit, P, Manlucu, J, Purves, PD, Skanes, AC, Tang, ASL, Yee, R. Strategies for ECG Arrhythmia Diagnosis: Breaking Down Complexity. Minneapolis, MN: Cardiotext Publishing; 2016
18. Fogoros R. Electrophysiologic Testing. 4th edition. Malden, MA: Blackwell Publishers, 2006
19. Murgatroyd, F, Krahn, AD, Yee R, Skanes A, Klein GJ. Handbook of Cardiac Electrophysiology: A Practical Guide to Invasive EP Studies and Catheter Ablation. 1st Edition. Remedica Publishing, 2002
20. Ellenbogen, KA, Tung, R, Frankel, D, Guha, P, Ho, R. Essential Concepts of Electrophysiology through Case Studies: Intracardiac EGMS. Minneapolis, MN: Cardiotext Publishing; 2015
21. Klein, GJ, et. al. Electrophysiological Maneuvers for Arrhythmia Analysis. Minneapolis, MN: Cardiotext Publishing; 2014
22. Prystowsky E and Klein G. Cardiac arrhythmias. An Integrated Approach for the Clinician. New York, NY: McGraw-Hill, 1994
23. Huang SK, Wood MA. Catheter Ablation of Cardiac Arrhythmias. Philadelphia, PA: W.B. Saunders, 2006
24. Friedman, PA, Tempel, ND, Mulpuru, SK, Cha, YM, Asirvatham, SJ, Hayes, DL. A Case-Based Approach to Pacemakers, ICDs, and Cardiac Resynchronization: Questions for Examination Review and Clinical Practice. vol 3. Minneapolis, MN: Cardiotext Publishing; 2016
25. Friedman PA, Rott MA, Wokhlu A, Asirvatham SJ, Hayes DL. A Case-Based Approach to Pacemakers, ICDs, and Cardiac Resynchronization: Introductory AND Advanced Questions

for Examination Review and Clinical Practice (2 volume set). Minneapolis, MN: Cardiotext Publishing; 2013

26. Hayes DL, Friedman RA. Cardiac Pacing, Defibrillation and Resynchronization: A Clinical Approach. 3 ed. Hoboken NJ: Wiley-Blackwell, 2008
27. Swerdlow C & Friedman P Advanced ICD Troubleshooting Part I PACE 2005; 28: 1322-1346
28. Swerdlow C & Friedman P Advanced ICD Troubleshooting Part II PACE 2006;29(1):70-96
29. Abraham WT, Fisher WG, Smith AL, Delurgio DB, Leon AR, Loh E, Kocovic DZ, Packer M. Cardiac Resynchronization in Chronic Heart Failure. New England Journal of Medicine 2002; 346(24): 1845-1853
30. McAllister FA Cardiac Resynchronization Therapy for Patients with Left Ventricular Systolic Dysfunction A Systematic Review JAMA 2007 297: 2502-2514
31. Walsh EP, Saul JP, Triedman J (eds.). Cardiac Arrhythmias in Children and Young Adults with Congenital Heart Disease. Baltimore, MD: Williams & Wilkins, 2001
32. Allen HD, Driscoll DJ, Shaddy RE, Feltes TF (eds). Moss and Adams' Heart Disease in Infants, Children and Adolescents. Philadelphia, PA: Wolters Kluwer / Lippincot Williams & Wilkins, 2008 (Part III: Electrophysiology, Chapters 10-15; Part IV: Therapeutic Methods, Chapter 17).