PENNSTATE
Milton S. Hershey Medical Center
College of Medicine

EP FELLOWSHIP CORE CURRICULUM

Introduction

The clinical cardiac electrophysiology fellow will be given the opportunity to acquire a full range of basic and clinical knowledge and skills beyond the level necessary to independently assume the responsibilities of an academic or practicing electrophysiologist. The core curriculum follows all the recommended guidelines published by The Heart Rhythm Society (HRS), The American College of Cardiology (ACC), The American Heart Association (AHA), and The Accreditation Council for Graduate Medical Education (ACGME). Included in the curriculum are Guidelines and Policies necessary for the staff electrophysiologist to remain in good standing at our institution (See Fellow Guidelines).

Basic Electrophysiology

As with every aspect of the curriculum, the fellow will be evaluated based on the ACGME core competencies – patient care (compassionate, appropriate, effective), medical knowledge (established and evolving protocols and application to patient care), practice-based learning and improvement (continuous assessment and quality improvement), interpersonal and communication skills (effective information exchange with patients, colleagues and associates), professionalism (ethics and sensitivity of diversity), and systems-based practice (awareness of larger context of health care system). The basic electrophysiology component of the ACC EPSAP will be reviewed in detail.

Objectives: To learn the normal electrophysiology of the human heart. Specifically, this includes obtaining an understanding of the electrophysiology of the atrial and ventricular myocardium, sinus node, AV node, and His-Purkinje system under normal conditions. To understand the origins of disturbances in the normal heart rhythm, the basic pharmacological properties and actions of antiarrhythmic agents, and basic effects of the autonomic nervous system on both. Special emphasis is placed on applying this knowledge to patient care in a clinical setting and effectively communicating with the patient, as well as research protocols. To apply this medical knowledge in a clinical patient care setting.

1. Determinants of normal cardiac rhythm
    a. Origins of resting potentials, channels and ionic currents
    b. Differences between fast and slow response action potentials
    c. Location of fast and slow action potentials
2. Determinants of normal conduction
    a. Understanding of cell to cell interaction and conductance
    b. Electronus
    c. Fiber diameter
    d. Passive membrane potential
    e. Upstroke velocity
    f. Autonomous nervous system influences on all factors of conduction
3. Genesis of arrhythmias
    a. Abnormal impulse initiation
        i. Abnormal automaticity
        ii. Altered automaticity
        iii. Triggered activity – early and delayed after potentials
    b. Disordered impulse propagation
        i. Slow response
        ii. Depressed fast response
        iii. Re-entry
        iv. Reflection
        v. Anisotropic conduction

c. Autonomic nervous system effects on all factors of genesis
d. Protocols for treatment
e. Patient care basics
i. Effective treatment
ii. Sensitivity
iii. Treating the whole patient
f. Ethical responsibilities

4. Antiarrhythmic drug actions
a. Mechanism(s) of action
b. Drug-receptor interactions
c. Modulated and guarded receptor hypothesis
d. Cellular electrophysiological effects of the various classes of drugs
e. Modulation of drug effects by metabolic alterations

Basic Pharmacokinetics and Pharmacodynamics

The fellow will be evaluated based on the ACGME core competencies – patient care (compassionate, appropriate, effective), medical knowledge (established and evolving protocols and application to patient care), practice-based learning and improvement (continuous assessment and quality improvement), interpersonal and communication skills (effective information exchange with patients, colleagues and associates), professionalism (ethics and sensitivity of diversity), and systems-based practice (awareness of larger context of health care system). These competencies will be covered in-depth in our lecture series.

Objectives: To understand how the autonomic nervous system, ischemia, electrolyte disturbances, cardiac disease and other conditions affect cardiac electrophysiology and alter the pharmacological properties of antiarrhythmic drugs. To learn the indication, limitations and risks of available and experimental pharmacological treatments for rhythm disturbances. Special emphasis is placed on current patient care protocols and communication with patient on effectiveness, efficacy, interactions and pros and cons of medical therapy. To apply this medical knowledge in a clinical patient care setting. Additional emphasis is placed on emerging medical therapies and continued research protocols.

1. Basic pharmacokinetic principles
a. Absorption
i. Effect of lipid solubility
ii. Ionic changes on absorption
b. Distribution
i. Apparent vs. anatomic volumes
ii. Tissue and protein binding
c. Metabolism
i. Hepatic and non-hepatic mechanisms
ii. First pass
iii. Induction
iv. Inhibition by other factors
d. Elimination
i. Liver
ii. Lung
iii. Kidney
iv. T1/2
v. Zero/first order kinetics
vi. Dose-dependent kinetics
e. Clearance
i. T1/2
ii. Steady state
iii. Compartmental analysis
f. Receptor theory
g. Structure-activity relationships

    h. Agonist, antagonist
    i. Therapeutic index
2. Pharmacodynamics and pharmacokinetics of antiarrhythmic agents
    a. Classes of antiarrhythmic drug action
    b. Effects of drugs on conduction and refractoriness of myocardial tissue
    c. Channel-blocking drugs
    d. Drug indications
    e. Contraindications
    f. Dosages
    g. Interactions
    h. Adverse effects
    i. Elimination T1/2 in renal, hepatic or heart failure
3. Pharmacological treatment of arrhythmia patients
    a. Patient communication
    b. Ethical obligations
    c. Improving patient care
    d. Treating the whole patient

Arrhythmias

The fellow will be evaluated based on the ACGME core competencies – patient care (compassionate, appropriate, effective), medical knowledge (established and evolving protocols and application to patient care), practice-based learning and improvement (continuous assessment and quality improvement), interpersonal and communication skills (effective information exchange with patients, colleagues and associates), professionalism (ethics and sensitivity of diversity), and systems-based practice (awareness of larger context of health care system).

Objectives: To learn the pathogenesis of the full gamut of arrhythmias, related symptom complexes and syndromes, and neurocardiac diseases and to understand the technique, application, indications, limitation, sensitivity and specificity of the various non-invasive and invasive diagnostic tests. These arrhythmias and clinical syndromes include sinus node dysfunction, heart block due to AV node and His-Purkinje dysfunction; supraventricular tachycardias; ventricular tachycardias; resuscitated sudden cardiac death; patient population at risk of sudden cardiac death; syncope; palpitations; long QT and other hereditary arrhythmia syndromes; proarrhythmic complications; and neurocardiogenic syncope syndromes. To learn the indication, limitations and risks of available and experimental pharmacological and non-pharmacological treatments for the above disorders. Specific non-pharmacological approaches include catheter ablation, pacemakers, implantable defibrillators, surgical ablation, and implantable pharmacological devices. To apply this medical knowledge in a clinical patient care setting.

1. Supraventricular
    a. Sinus node dysfunction
    b. Atrioventricular conduction abnormalities
    c. Supraventricular tachycardias
        i. Site of origins
        ii. Mechanisms
    d. Pre-excitation syndromes
    e. Differentiation of SVT with aberrancy from VT and WPW
2. Ventricular Tachyarrhythmias
    a. VPD
    b. VT
        i. Sustained
        ii. Non-sustained
        iii. Monomorphic
        iv. Polymorphic
        v. Bidirectional

c. Etiologies – associated types of underlying heart disease
    i. Myocardial infarction
    ii. Cardiomyopathy
    iii. RV dysplasia
    iv. Long QT syndromes
    v. Digitalis toxicity
    vi. Idiopathic
    vii. Verapamil sensitive
d. Definition and distinction
e. AV dissociation
f. Fusion or capture beats
g. QRS morphology

3. Arrhythmia patient care
    a. Appropriate care
    b. Effective communication
    c. Ethical obligations
    d. Treatment of the whole patient

Invasive Electrophysiology

The fellow will be evaluated based on the ACGME core competencies – patient care (compassionate, appropriate, effective), medical knowledge (established and evolving protocols and application to patient care), practice-based learning and improvement (continuous assessment and quality improvement), interpersonal and communication skills (effective information exchange with patients, colleagues and associates), professionalism (ethics and sensitivity of diversity), and systems-based practice (awareness of larger context of health care system).

Objective: To learn the indication, limitations and risks of available and experimental non-pharmacological treatments for the above disturbances - specifically, catheter ablation, pacemakers, implantable defibrillators, surgical ablation, and the emerging use of implantable pharmacological devices. To develop a thorough understanding of the indications, limitations, and risks of pacemaker and defibrillator implantation, and to improve implantation techniques. This also involves development of a thorough understanding of the appropriate use and risks of fluoroscopic imaging equipment and the management of acute complications such as cardiac tamponade. Particular emphasis will be placed on indications for implantation techniques for biventricular pacemakers, management of congestive heart failure, and prophylaxis for sudden cardiac death. To apply this knowledge to patient care settings to determine the most effective treatment plan.

1. Introductory principles
    a. Indications
    b. Data interpretation
    c. Therapeutic implications
    d. Sensitivity
    e. Specificity
    f. Normal conduction
    g. Resource
    h. Resource stimulator
    i. Recorders
    j. X-ray
    k. Emergency
2. Catheter techniques and risks
    a. Recording sites

    b. Risks
        i. Perforation
        ii. Hematoma
        iii. Bleeding
        iv. Thromboembolic pneumonia
        v. Arrhythmias
        vi. Tamponade
3. His Bundle recordings
    a. Recording
    b. Validation
4. Sinus and AV Node functions
    a. Sinus node recovery times (SNRT)
    b. Sino atrial conduction times (SACT)
    c. Intracardiac conduction intervals
        i. PA
            1. Sinus
            2. Pacing
        ii. AH
            1. Sinus
            2. Pacing
        iii. HV
            1. Sinus
            2. Pacing
        iv. H-RB
            1. Sinus
            2. Pacing
5. Refractory periods
    a. Atrial
    b. Ventricular
    c. AV Node
    d. His Purkinje
    e. Ventricular conduction
        i. Normal
        ii. Eccentric
    f. Concealed conduction
    g. Gap phenomena
6. Atrioventricular Block/Intraventricular Conduction Defects
    a. Natural history
        i. Av Nodal
        ii. Intrahisian
        iii. Infrahisian
    b. Fascicular blocks
        i. Uni
        ii. Bi
        iii. Tri
    c. Bundle branch block
        i. Functional
        ii. Rate dependent
        iii. Alternating
        iv. Prolonged HV
    d. Prognostic significance
        i. Acute myocardial infarction
        ii. Fascicular block(s)
    e. Atrial pacing induced infra AV Nodal block

f. Permanent pacing indications related to AV block site
    i. Congenital
    ii. Chronic
    iii. Acute infarction
g. Antiarrhythmic drugs
    i. Effect on autonomic nervous system
    ii. Effect on AV conduction

7. Supraventricular Tachycardia
    a. Pacing techniques
        i. Atrial overdrive pacing
        ii. Atrial extrastimulation
        iii. Ventricular pacing
        iv. Ventricular extrastimulation
    b. Types
        i. Clinical criteria
        ii. ECG criteria
        iii. Electrophysiologic criteria
    c. Accessory pathway location by 12 lead ECG
        i. WPW Syndrome
    d. Mechanisms
        i. Intraatrial
            1. Sinus
            2. Sinoatrial re-entrant
            3. Atrial-automatic
            4. Re-entrant
            5. Miltifocal
            6. Atrial flutter
            7. Atrial fibrillation
        ii. AV junctional
            1. AV Nodal re-entrant
                a. Typical
                b. Atypical
            2. Automatic
                a. Junctional automatic tachycardia
                b. Nonparoxysmal junctional tachycardia
        iii. Atrioventricular reciprocating (re-entrant) tachycardia
            1. Orthodromic
            2. Antidromic
            3. Nodoventricular
            4. atriofascicular
            5. Permanent form of AV junctional re-entrant tachycardia (PJRT)

e. Site origins
    i. Intraatrial
        1. Sinus
        2. Sinoatrial re-entrant
        3. Atrial-automatic
        4. Re-entrant
        5. Miltifocal
        6. Atrial flutter
        7. Atrial fibrillation
    ii. AV junctional
        1. AV Nodal re-entrant
            a. Typical
            b. Atypical
        2. Automatic
            a. Junctional automatic tachycardia
            b. Nonparoxysmal junctional tachycardia
    iii. Atrioventricular reciprocating (re-entrant) tachycardia
        1. Orthodromic
        2. Antidromic
        3. Nodoventricular
        4. atriofascicular
        5. Permanent form of AV junctional re-entrant tachycardia (PJRT)
    iv. Electrophysiologic assessment
        1. Endocardial pacing
        2. Mapping studies to localize origin and pathway site
        3. EP ECG interpretation
        4. Pharmacologic indications
            a. Vagolytic agents
            b. Vagomimetic agents
            c. Sympathomimetic agents
            d. Beta blocking agents
        5. Assessment of drug effects at EP testing
        6. Serial EP testing indications
        7. Antitachycardia pacing
        8. Indications fro catheter or surgical ablation

8. Ventricular tachycardia
    a. Differential diagnosis of wide QRS
    b. Criteria
        i. VT
        ii. Bundle branch
        iii. Re-entrant
    c. Programmed stimulation protocols
        i. Minimal
        ii. Recordings
        iii. Interpretation
    d. Characteristics
        i. Automatic
        ii. Re-entrant
        iii. Triggered
    e. Sensitivity and specificity induction
        i. Sustained
        ii. Non-sustained
        iii. Monomorphic
        iv. Polymorphic
        v. Ventricular fibrillation

f. Pacing termination protocols
    i. Burst
    ii. Adaptive
    iii. Scanning extrastimuli

9. Pacemaker/ICD implantation
    a. Instrumentation
    b. Patient preparation
        i. Monitoring
        ii. Site
    c. Techniques
    d. Analysis and electrophysiologic testing
        i. Pacing threshold
        ii. Sensing electrogram recoding
        iii. Slew rate
        iv. VA conduction
        v. Pacemaker syndrome
        vi. Complications
            1. Immediate
            2. Late
        vii. Troubleshooting
        viii. Documentation
        ix. DFT testing

10. Sudden cardiac death
    a. Presentations
    b. At risk patients
        i. Post acute MI
        ii. Cardiomyopathy
        iii. Long QT
        iv. Drug toxicity
    c. Programmed ventricular stimulation
        i. Indications
        ii. Sensitivity
        iii. Specificity
        iv. Drug-facilitated patients
        v. Congenital Long QT
        vi. Acquire Long QT
        vii. Exercise-induced VT

11. Arrhythmia mapping techniques
    a. Interpretation of local electrograms
        i. Effects of filtering
        ii. Local activation times of tachycardias
        iii. Late potentials
        iv. Low amplitude potentials
        v. Fractionated electrograms
        vi. Continuous electrical activity

b. Endocardial catheter mapping
    i. Indications
        1. Patients with VT
        2. Patients with SVT
    ii. EP concepts
        1. Entrainment
        2. Resetting
        3. Fusion
        4. Activation
        5. Entry or exit block resulting from pacing intervention
    iii. Activation and potential mapping with multiple electrograms
    iv. Catheterization safety
        1. Hemodynamic compromise
        2. Ischemic compromise
c. Intraoperative mapping
    i. Computer-aided multichannel recorders
    ii. Understanding surgical ablation
        1. WPW mapping
            a. Pacing induction
            b. AV groove mapping
            c. Early ventricular activation
            d. Atrial activation
        2. Problems
            a. Multiple VT morphologies
            b. Anesthetic effects
            c. Geometry distortions of VT morphology
        3. Earliest site of origin
            a. Endocardial mapping
            b. Epicardial mapping

12. Antitachycardia devices
    a. Patient Assessment
        i. Pacemakers for bradycardia
        ii. Cardioverter defibrillators (ICD) for tachycardia
        iii. Physiology of electrical stimulation
        iv. Genesis of endocardial electrogram
        v. Basic pulse generator design and function
            1. Pacemakers
            2. ICDs
        vi. Pacemakers
            1. Guidelines
            2. Indications
            3. Contraindications
            4. Type
        vii. ICDs
            1. Guidelines
            2. Indications
            3. Contraindications
            4. Type
        viii. Implantation testing
            1. Threshold testing
            2. Electrogram recording
        ix. Device complications
        x. Device and antiarrythmic drug interactions
        xi. Follow-up methods
            1. Pacemakers
            2. ICDs

13. RF Catheter Ablation-Tachycardias
    a. Introduction
        i. Appropriate patient selection
        ii. Indications
        iii. Complications
        iv. Physics of current delivery
        v. Pathology of tissue damage
        vi. Peak voltage and current delivered
            1. Impedance characteristics
            2. Temperature
    b. Atrioventricular nodal re-entrant tachycardia (AVNRT)
        i. Indications
        ii. Potential complications – AV block
        iii. Catheter placement
        iv. Patch placement
        v. Range of energies
        vi. Fast vs. slow pathway ablation
        vii. Anatomical or pathway potential guided
        viii. Efficacy
    c. Atrioventricular re-entrant tachycardia (AVRT)
        i. Mapping of tricuspid and mitral rings for pathway potentials
        ii. Classification of pathways
            1. Free wall
            2. Anterior septal
            3. Posterior septal
        iii. Efficacy
        iv. Potential complications
    d. Atrioventricular junction ablation
        i. Indications for inducing AV block
        ii. Hemodynamic consequences of complete AV block
        iii. His bundle recordings
    e. Ventricular tachycardia (VT)
        i. Mapping
        ii. Catheter placement
        iii. Exit block localization
            1. Overdrive pacing
            2. Premature ventricular stimulation
        iv. Indications
        v. Appropriate patient selection
        vi. Contraindications
        vii. Energy ranges
        viii. Alternative energy sources
    f. Atrial flutter/tachycardia
        i. Mapping
        ii. Catheter placement
        iii. Efficacy
14. Surgical treatment of tachycardia
    a. Atrial fibrillation
        i. MAZE procedure
            1. Indications
            2. Patient selection
    b. VT
        i. Risks
        ii. Determinants of post-op mortality and morbidity

c. Intra-op techniques
    i. Localizing His bundle
    ii. Localizing accessory pathways
    iii. Localizing tachycardia foci
d. Current techniques
e. Limitations
f. Potential benefits

15. Invasive electrophysiology patient care
    a. Appropriate care
    b. Effective communication
        i. Sensitivity
        ii. Outlining the plan of care
        iii. Outlining alternate treatment plans
        iv. Discussing treatment risks and benefits
    c. Ethical obligations
    d. Treatment of the whole patient

Device Management

The fellow will be evaluated based on the ACGME core competencies – patient care (compassionate, appropriate, effective), medical knowledge (established and evolving protocols and application to patient care), practice-based learning and improvement (continuous assessment and quality improvement), interpersonal and communication skills (effective information exchange with patients, colleagues and associates), professionalism (ethics and sensitivity of diversity), and systems-based practice (awareness of larger context of health care system).

Objective: To develop a thorough understanding of the management of permanent pacemakers and implantable cardioverter defibrillators (ICDs), including troubleshooting and implantable device-related problems. To gain an advanced understanding of electrocardiographyas well as other non-invasive risk stratifying studies such as signal-averaged electrocardiography, T wave alternans testing, heart rate variability, and autonomic testing. To further the fellow's patient management and consulting skills for patients with all types of arrhythmias or arrhythmia-related problems. To apply the medical knowledge gained to patient care settings to determine the most effective treatment plan.

1. Pacemaker Service
    a. Patient Follow-up
        i. History
        ii. Physical exam
        iii. Chest x-ray
            1. Lead position integrity
            2. Generator orientation
        iv. ECG
        v. Telemetered pacemaker data
        vi. Telemetered pacemaker programming
    b. Indications for permanent pacemakers
    c. Mode codes
        i. 5 positions
        ii. Prescription
    d. Electrocardiography
    e. Rates
        i. Lower limits
        ii. Upper limits
        iii. Magnet rates
        iv. Hysteresis
        v. Fallback AV intervals
        vi. Pacing timing cycles

f. Programmability
    i. Rate
    ii. Output
g. Evaluation of atrial capture
h. Atrial pacing systems
i. Troubleshooting
    i. Undersensing
    ii. Oversensing
    iii. Crosstalk
j. Rapid paced ventricular rates
    i. PMT
    ii. Tracting of rapid atrial rates
k. Rate adaptive systems
l. Evaluation of chronotropic incompetence
m. End of life (EOL) indicators
n. Elective replacement (ERI) indicators
o. Management of external magnetic interference (EMI)

2. Pacing
    a. Physiology of electrical stimulation
    b. Genesis of endocardial electrogram
    c. Basic pulse generators
        i. Design
        ii. Function
    d. Leads
        i. Active
        ii. Passive
        iii. Uni-polar
        iv. Bi-polar
        v. Insulation
        vi. Sensor types
        vii. Epicardial
        viii. Endocardial
    e. Indications for device implantation
        i. Bradycardia
        ii. Tachycardia
    f. Proper prescription
    g. Contraindications
    h. Complications
        i. Single chamber
        ii. Dual chamber
        iii. Rate adaptive devices
        iv. Antitachycardia devices
    i. Device interactions
        i. Drugs
        ii. Other devices
    j. Analyzer function and operation
        i. Measurements
        ii. Minimal acceptable PSA measurements
    k. Post-implant complications
    l. Device malfunction – differential diagnosis
    m. Use of external programmers

3. Electrocardiography
    a. Indications
        i. Overt cardiovascular disease
        ii. Suspected cardiovascular disease
        iii. Assess therapy results
        iv. Patient age and risk factors
            1. Hypercholesterolemia
            2. Diabetes
            3. Obesity
            4. Smoking
            5. Positive family history
        v. Pre-op assessment
        vi. Diseases and additional factors
            1. Renal failure
            2. Diabetic acidosis
            3. Hypothermia
            4. Electrolyte abnormalities
            5. Toxic drugs
            6. Miscellaneous
    b. Complications
        i. Inappropriate interpretation
        ii. Underestimation
            1. Sensitivity
            2. Specificity
            3. Predictive value
        iii. Patient disease as a result of above
    c. Techniques
        i. Electrode placement
        ii. Lead reversals
        iii. Standardization
        iv. Paper speed
        v. Artifacts
        vi. Muscle tremor
    d. Normal Ecg
    e. QRS
        i. Axis
        ii. Rotation
        iii. Position
    f. Arrhythmias
        i. Rhythm
        ii. Cardiac
    g. Av conduction
        i. AV block
        ii. VA conduction
    h. Intraventricular conduction
        i. BBB
        ii. Fascicular blocks
        iii. Anomalous and aberrant conduction
    i. Hypertrophy
        i. Atrial
        ii. Ventricular
            1. Right
            2. Left
    j. Ischemia
    k. Infarction
    l. Pacemaker rhythms

m. ECG patterns
    i. Dextrocardia
    ii. Long QT
    iii. Mitral stenosis
    iv. Chronic lung disease
    v. CVA
    vi. Tamponade
    vii. Pericarditis
    viii. Pulmonary embolism
    ix. Hyperthermia
    x. Hypothermia
    xi. Electrolyte imbalances
    xii. Antiarrhythmic drug effects

4. Ambulatory ECG Monitoring
    a. Continuous analog tape monitoring (Holter)
        i. Duration
        ii. Indications
        iii. Use
            1. Risk stratification post acute MI
            2. Documenting ischemic ST changes
            3. Evaluating antiarrhythmic therapy
    b. Patient activated short term event recorders
        i. Types
            1. Hand held
            2. Memory loop
        ii. Indications
5. Signal-Averaged ECG (SAECG)
    a. Late potential
    b. Indications
        i. Risk stratification after myocardial infarction for sustained VT
        ii. Dilated cardiomyopathy
        iii. RV dysplasia
        iv. Syncope
    c. Criteria
        i. 40-Hz high-pass filter
            1. QRS duration
            2. Root mean square (RMS) vector magnitude
            3. Low amplitude signal (LAS)
        ii. 25-Hz high-pass filter
            1. QRSD
            2. RMS
            3. LAS
    d. Prognostic value
        i. Post-MI
            1. Patient population
            2. Effectiveness
            3. Sensitivity and specificity ranges
        ii. Other patient populations
    e. Natural history of late potentials
        i. Post acute MI
        ii. Late potential development
    f. Syncope and late potentials
        i. VT induced
        ii. Sensitivity and specificity
        iii. False positives
        iv. False negatives

6. Tilt table testing
    a. Indications
        i. Vasovagal syncope
        ii. Unexplained syncope
    b. Methods
        i. Standards
        ii. Foot boards
        iii. False positives
        iv. Head angle
        v. Duration
        vi. Drugs
        vii. Sensitivity
        viii. Reproducibility
            1. Positive tilt
            2. Negative tilt
            3. Variability ranges
        ix. Predicting therapy
        x. Provocation
            1. Isoproterenol
            2. NTG
            3. Edrophonium
            4. Epinephrine
            5. ATP
7. Exercise testing
    a. Indications
        i. Reproducing arrhythmias brought on by exercise
        ii. Judge drug efficacy or proarrhythmia
        iii. Determine drug efficacy in rate control during AFIB
        iv. Evaluate rate responsive pacemakers
    b. Standards
    c. Methods
8. Heart Rate Variability
    a. Standards
    b. Indications
9. Device patient care
    e. Appropriate care
    f. Effective communication
        i. Sensitivity
        ii. Outlining the plan of care
    g. Ethical obligations
    h. Treating the whole patient

Patient Care

Fellows must be able to provide patient care that is compassionate, appropriate, and effective for the treatment of health problems and the promotion of health.
Fellows are expected to:

- Communicate effectively and demonstrate caring and respectful behaviors
- When interacting with patients and their families gather essential and accurate information about their patients to make informed decisions about diagnostic and therapeutic interventions based on patient information and preferences, up-to-date scientific evidence, and clinical judgment
- Develop and carry out patient management plans
- Counsel and educate patients and their families
- Use information technology to support patient care decisions and patient education
- Perform competently all medical and invasive procedures considered essential for the area of practice
- Provide health care services aimed at preventing health problems or maintaining health
- Work with health care professionals, including those from other disciplines, to provide patient-focused care

Medical Knowledge

Fellows must demonstrate knowledge about established and evolving biomedical, clinical, and cognate (e.g. epidemiological and social-behavioral) sciences and the application of this knowledge to patient care.
Fellows are expected to:

- Demonstrate an investigatory and analytic thinking approach to clinical situations
- Know and apply the basic and clinically supportive sciences which are appropriate to their discipline

Practice-Based Learning And Improvement

Fellows must be able to investigate and evaluate their patient care practices, appraise and assimilate scientific evidence, and improve their patient care practices.
Fellows are expected to:

- Analyze practice experience and perform practice-based improvement activities using a systematic methodology
- Locate, appraise, and assimilate evidence from scientific studies related to their patients'' health problems
- Obtain and use information about their own population of patients and the larger population from which their patients are drawn
- Apply knowledge of study designs and statistical methods to the appraisal of clinical studies and other information on diagnostic and therapeutic effectiveness
- Use information technology to manage information, access on-line medical information; and support their own education
- Facilitate the learning of students and other health care professionals

Interpersonal And Communication Skills

Fellows must be able to demonstrate interpersonal and communication skills that result in effective information exchange and teaming with patients, their patients families, and professional associates.
Fellows are expected to:

- Create and sustain a therapeutic and ethically sound relationship with patients
- Use effective listening skills and elicit and provide information using effective nonverbal, explanatory, questioning, and writing skills
- Work effectively with others as a member or leader of a health care team or
- Other professional groups

Professionalism

Fellows must demonstrate a commitment to carrying out professional responsibilities, adherence to ethical principles, and sensitivity to a diverse patient population.
Fellows are expected to:

- Demonstrate respect, compassion, and integrity; a responsiveness to the needs of patients and society that supercedes self-interest; accountability to patients, society, and the profession; and a commitment to excellence and on-going professional development
- Demonstrate a commitment to ethical principles pertaining to provision or withholding of clinical care, confidentiality of patient information, informed consent, and business practices
- Demonstrate sensitivity and responsiveness to patients'' culture, age, gender, and disabilities

Systems-Based Practice

Fellows must demonstrate an awareness of and responsiveness to the larger context and system of health care and the ability to effectively call on system resources to provide care that is of optimal value.
Fellows are expected to:

- Understand how their patient care and other professional practices affect other health care professionals, the health care organization, and the larger society and how these elements of the system affect their own practice
- Know how types of medical practice and delivery systems differ from one another, including methods of controlling health care costs and allocating resources
- Practice cost-effective health care and resource allocation that does not compromise quality of care
- Advocate for quality patient care and assist patients in dealing with system complexities
- Know how to partner with health care managers and health care providers to assess, coordinate, and improve health care and know how these activities can affect system performance

Literature

Textbooks

1. Josephson ME: Clinical Cardiac Electrophysiology: Techniques and Interpretation. 2nd edition. Lea & Febiger, Philadelphia, 1993.
2. Zipes DP and Jalife J: cardiac Electrophysiology: From Cell to Bedside. 2nd edition. W.B. Saunders Company, Philadelphia, 1995.
3. EPSAP: Electrophysiology Self-Assessment Program. G.V. Naccarelli, editor-in-chief. American College of Cardiology and North American Society of Pacing and Electrophysiology, 1996.

Literature/Guidelines

1. Guidelines for clinical intracardiac electrophysiology and catheter ablation procedures: a report of the American College of Cardiology/AHA Task Froce on Practical Guidelines developed in collaboration with NASPE. J Am Coll Cardiol. 1995:26;555-573.
2. Guidelines for clinical intracardiac electrophysiologic studies: a report of the American College of Cardiology/AHA Task Force on Assessment of Diagnostic and Therapeutic Cardiovascular Procedures. J Am Coll Cardiol. 1998;14:1827-1842.
3. Dreifus LS, Fisch C, Griffin JC, et al. Guidelines for implantation of cardiac pacemakers and antiarrhythmic devices: a report of the American College of Cardiology/AHA Task Force on Assessment of Diagnostic and Therapeutic Cardiovascular Procedures. Circulation 1991;84:455-467.
4. Task Force of the Working Group on Arrhythmias of the European Society of Cardiology. The Sicilian Gambit. A new approach to the classification of antiarrhythmic drugs based on their actions on arrhythmogenic mechanisms. Circulation 1991;84:1831-1851.
5. Clinical competence in invasive cardiac electrophysiological studies. ACP/ACC/AHA Task Force on Clinical Privileges in Cardiology. J Am Coll Cardiol. 1994;23:1258-1261.
6. Clinical competence in cardiac electrocardiography. ACP/ACC/AHA Task Force on clinical privileges in Cardiology. J Am Coll Cardiol. 1995;25:1465-1469.
7. Heart rate variability for risk stratification of life-threatening arrhythmias. American College of Cardiology Cardiovascular Technology Assessment Committee. J Am Coll Cardiol. 1993;22:948-950.

Rotations

1: Clinical EP Lab
2: Clinical EP Lab
3: Clinical EP Lab
4: Cardiac Care Unit
5: Outpatient Clinic
6: Outpatient Clinic
7: Non-invasive & Device Follow-up
8: Non-invasive & Device Follow-up
9: Inpatient EP Service
10: Inpatient EP Service
11: Clinical EP & Device Lab
12: Clinical EP & Device Lab

CCEP – Timeline for Competency Assessment	
Level 1[1] – General Cardiology Fellowship: Cardiac Arrhythmia and EP Core	
Skills	
Description	**Time Frame**
Knowledge and experience in the diagnosis and management of bradyarrhythmias and tachyarrhythmias	By 2 months
Indications for and limitations of electrophysiologic studies,	By 2 months
The appropriate use of pharmacological and nonpharmocologic therapeutic options	By 2 months
Proper and appropriate use of antiarrhythmic agents, including drug interactions and proarrhythmic potential	By 2 months
Exposed to noninvasive and invasive techniques related to the diagnosis and management of patients with cardiac arrhythmias that include ECG monitoring, event recorders, exercise testing for arrhythmia assessment, tilt table testing, and implantation of cardiac arrhythmia control devices	By 2 months
Basic ECG training on manifestations of arrhythmias	By 1 year
Didactic sessions and conferences in heart rhythm disorders and clinical correlations	By 1 year
Experience as a consultant in arrhythmia management with training and experience in arrhythmias associated with congenital heart disease, cardiac and noncardiac surgical patients, and pre- and post-cardiac transplantation patients	By 1 year
Formal instruction and experience with insertion, management, and follow-up of temporary pacemakers	By 1 year
Formal instruction and experience with measuring pacing and sensing thresholds and recording electrograms for management of patients with temporary pacemakers	By 1 year
Formal training and experience with indications and techniques for elective and emergency cardioversions	By 1 year
Insertion of a minimum of 10 temporary pacemakers	By 1 year
Performance of at least 8 cardioversions	By 1 year
Level 2[1] – General Cardiology Fellowship: Advanced Noninvasive	
Skills	
Description	**Time Frame**
Minimum of 6 months training as a noninvasive cardiac arrhythmia specialist with advanced competency and proficiency in the diagnosis, treatment and longitudinal care of patients with complex arrhythmias	After 6 months
Advanced training in normal and abnormal cardiac electrophysiology and mechanisms of arrhythmias	After 6 months
Proficiency in the performance and interpretation of noninvasive diagnostic clinical procedures such as ambulatory ECG monitoring, signal-averaged electrocardiography, tilt table testing, heart rate variability, and other tests of the autonomic nervous system	After 6 months
Acquire knowledge of basic and clinical pharmacology of antiarrhythmic agents and proficiency in their use	After 6 months
Acquisition of skills and experience for managing inpatients and outpatients with complex cardiac arrhythmias, including programming and follow-up management of all types of bradycardia pacing systems	After 6 months
Ability to function as the primary operator who interrogates, interprets, prescribes, and reprograms in at least 100 patients	After 6 months
Acquire advanced expertise in temporary pacing	After 6 months
Acquire advanced expertise in transesophageal atrial pacing	After 6 months
Acquire advanced expertise in cardioversion	After 6 months
Acquire advanced expertise in invasive electrophysiologic study data	After 6 months
Acquire advanced expertise in complex arrhythmia ECG interpretation	After 6 months
Significant exposure to invasive electrophysiology, implantable cardioverter defibrillators and the surgical aspects if arrhythmia control device implantation	After 6 months

CCEP – Timeline for Competency Assessment	
Level 3[1] – CCEP Fellowship Training	
EPS[1,2]	
Technical Skills	
Description	**Time Frame**
Operational skills to perform right and left heart catheterization and arterial access percutaneous techniques via femoral and other venous and arterial access sites	1 month
Manual dexterity to safely place and manipulate electrode catheters in the appropriate chambers for the arrhythmia under study	6 months
Ability to obtain appropriate recordings from various locations	6 months
Ability to safely perform programmed electrical stimulation	1 year
Ability to recognize and manage procedural complications (e.g. vascular or cardiac perforation)	3 months
Proficiency in the use of external defibrillation and intravenous cardiac medications	3 months
Proficiency in the appropriate use of sedation during procedures, including airway management	1 year
Proficiency in the testing, interrogation, and programming of implantable antiarrhythmic devices, including pacemakers and defibrillators	1 year
Technical knowledge regarding the use of recording equipment, including knowledge of electrical safety and pertinent radiation-related issues	1 year
Each trainee should be a primary operator and analyze 100-150 diagnostic studies, at least 50 of the studies should involve patients with supraventricular arrhythmias	After 2 years
Trainee should be the primary operator during $\geq$ 50 electrophysiological evaluations of implantable antiarrhythmic devices	After 2 years
Experience with at least 10 transseptal catheterization procedures	1 year
Cognitive Skills	
Description	**Time Frame**
Thorough understanding of the basic electrophysiological mechanisms and clinical manifestations of arrhythmias	1 year
Knowledge of applications and limitations of the available recording and stimulations technologies	1 year
Knowledge of current indications for an EPS	6 months
Knowledge of contraindications for an EPS (Absolute contraindications include unstable ischemia, bacteremia or septicemia, acute decompensated heart failure not caused by the arrhythmia, major bleeding diathesis, and lower extremity venous thrombosis, if femoral vein cannulization is desired)	6 months
Knowledge of potential complications and management of such complications	1 year
Knowledge of normal and abnormal cardiac anatomy and electrophysiology	6 months
Knowledge of the anatomy and physiology of the normal AV conduction system and accessory pathways	6 months
Understanding of the intracardiac electrocardiographic signals	1 year
Knowledge of the various methods of programmed electrical stimulation	6 months
Ability to measure conduction intervals and refractory periods and knowledge of their significance in normal pathological states	3 months
Knowledge of the predictive value of electrophysiological testing in patients with various arrhythmias and clinical syndromes	6 months
Knowledge of pharmacological effects of medications used during the studies	3 months
Ability to interpret data derived from electrophysiological testing	6 months
Knowledge of the indications for and complications of therapy with antiarrhythmic devices	6 months
Knowledge of the pharmacology of antiarrhythmic drugs and of sympathetic and parasympathetic agonists and antagonists	1 year
Knowledge of the indications for and complications of (risks, benefits and applications) ablative therapy	1 year
Detailed knowledge of recent clinical trials that affect the selection of patients for EPS	1 year
Familiarity with a diverse patient population who manifest a broad variety of arrhythmias	1 year

CCEP – Timeline for Competency Assessment	
Catheter Ablation[1,2]	
Skills	
Description	**Time Frame**
Participation in a minimum of 75 catheter ablations, including ablation and modification of the atrioventricular (AV) node, AV accessory pathways, atrial flutter, AV junction, and atrial and ventricular tachycardia	After 2 years
Primary operator in 15 accessory pathway ablations	After 2 years
Primary operator of $\geq$ 10 transspetal catheterizations	1 year
Proficiency in managing the bradyarrhythmia and AV heart block.	1 year
Knowledge of complications which may occur during catheter ablation, including valvular disruption, coronary occlusion, cerebrovascular accident and death	1 year
Knowledge of differentiating when to consider catheter ablation as a first-line therapy (e.g. a symptomatic patient with Wolff-Parkinson-White syndrome, or where medical therapy is intolerable, or evidence of adverse consequences of the arrhythmia), and when to use other therapeutic controls (e.g. in patients with rhythm disturbances that are likely to spontaneously resolve – atrial tachycardia, or unlikely to recur – a first episode of atrial flutter)	1 year
Ability to differentiate when AV node reentry is a benign arrhythmia or when catheter ablation is indicated (e.g. in patients with other compounding heart disease, such as coronary artery disease, or if the arrhythmia produces hemodynamic compromise or intolerable side effects)	1 year
Knowledge of the use of catheter ablation in the treatment of atrial fibrillation (AV node ablation and pacemaker implantation when medical therapy is not successful)	1 year
Knowledge of application of radiofrequency ablation in the treatment of ventricular tachycardia in ischemic disease, bundle-branch reentry and idiopathic tachycardia	1 year
Knowledge of risks and benefits associated with radiofrequency ablation in the treatment of ventricular tachycardia	1 year
Ability and dexterity to successfully manipulate catheters in all locations of the heart to achieve adequate contact between the catheter and the myocardium to create curative lesions	1 year
Detailed knowledge of the cardiac anatomy	1 year
Ability to perform transseptal catheterization for treatment of left-sided substrates such as left atrial foci and left-sided accessory pathways	1 year
Knowledge of transseptal and retrograde aortic technique	1 year

CCEP – Timeline for Competency Assessment	
Device Implantation[1,2]	
Skills – Tranvenous bradycardia device implantation (pacemaker)	
Description	**Time Frame**
Developing expertise in permanent atrial and ventricular lead placement	6 months
Developing expertise in threshold testing and programming of devices	3 months
Knowledge of principles of surgical asepsis	3 months
Knowledge of surgical techniques of implantation and management of implant-related complications	1 year
Must participate as the primary operator under direct supervision in at least 50 primary implantations, with at least half involving dual chamber pacemakers	1 year
Must participate as the primary operator under direct supervision in at least 20 pacemaker system revisions or replacements	1 year
Must participate in the follow-up of at least 100 pacemaker patient visits	1 year
Acquire proficiency in advanced pacemaker electrocardiography, interrogation and programming of complex pacemakers	1 year
Skills – Transvenous implantable cardioverter-defibrillator systems	
Description	**Time Frame**
Participate as the primary operator under the direct supervision in at least 20 system implantations	1 year
Must participate in the surgical replacement or revision of at least 10 systems	1 year
Must participate in the follow-up of at least 50 patient visits	1 year

CCEP – Timeline for Competency Assessment	
External DC Cardioversion[2]	
Technical Skills	
Description	**Time Frame**
Proper operation of the skin and electrode placement, including the application of saline jelly	3 months
Achievement of artifact-free monitored strip and synchronization signal/marker	1 month
Technically acceptable 12-lead electrocardiograms before and after DCCV	1 month
Temporary pacing and defibrillation capabilities	3 months
Ability to perform advanced cardiovascular life support, including proper airway management	1 month
External DC Cardioversion[2]	
Cognitive Skills	
Description	**Time Frame**
Knowledge of electrophysiological principles of DCCV	3 months
Knowledge of indications for the procedures	3 months
Knowledge of anticoagulation management	1 year
Knowledge of the proper use and administration of antiarrhythmic therapy	1 year