Lahey Clinic Medical Center

Cardiac Arrhythmia Service

Clinical Cardiac Electrophysiology Fellowship

Competency-Based Curriculum: Educational Objectives, Syllabus and Administrative Structure

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1.1: Introduction

Lahey Clinic is an internationally renowned private, non-profit tertiary care hospital distinguished for its multidisciplinary approach to medical care. The Lahey Clinic campus in Burlington Massachusetts forms the core hospital for a group practice of about 1000 physicians who are distributed in hospital and community sites in northern and eastern Massachusetts as well as in southern New Hampshire. The physician staff represent virtually every specialty and sub-specialty of medicine and surgery, and patients with complex conditions are treated expertly by a team approach.

The campus in Burlington houses 227 hospital, 8 CCU, 12 MICU, 12 SICU, and 50 telemetry beds; there are over 14,500 discharges and 32,000 Emergency Department visits annually. The Clinic accommodates almost 600,000 out patient visits per year, 15,000 of which are in the Section of Cardiology. The Cardiology group performs approximately 4500 echocardiograms, 1400 diagnostic cardiac catheterizations, 900 coronary interventions, and 1500 electrophysiologic procedures annually. For each of the last five years Lahey Clinic has been ranked in the top 50 US institutions providing specialist heart disease care and in 2002 Lahey was one of only three New England institutions so ranked. Many of the members of the Department of Cardiology are highly regarded by their peers as indicated by such publications as *Consumer's Guide to Top Doctors*.

Lahey Clinic provides training to a large number of medical students, medical and surgical residents, and sub-specialty fellows in both medical and surgical disciplines. In 1996 Lahey Clinic became a major teaching hospital for Tufts University School of Medicine. The institution possesses core residency programs in medicine and surgery as well as in most of the sub-specialty disciplines. The library has an extensive collection of 3000 current texts, 280 journal subscriptions, and 28,000 bound volumes.

The arrhythmia group within the Section of Cardiology offers a one or two year fellowship in clinical cardiac electrophysiology that is designed to provide a comprehensive sub-specialty training for individuals planning to pursue a career in this field. All fellows have completed the required three year training in internal medicine, and at least a further two years in cardiovascular diseases. After the satisfactory completion of this fellowship the graduate will be expected to be capable of functioning as an independent consultant and specialist in clinical cardiac electrophysiology. The Lahey program is predominantly clinical in its focus, with a wealth of clinical material from which to derive practical educational experiences.

Fellows in cardiac electrophysiology will be individuals who have completed internal medicine and cardiology training, and who can function at a level commensurate with such experience. Typically, the fellows will be compensated at the current Lahey Clinic salary level for PGY 6-7, and will receive malpractice coverage, medical and other benefits in accordance with the terms and conditions of employment outlined in the House Staff Manual. Fellows will be provided with private office space with a dedicated

telephone line and a personal computer for the fellows' exclusive use. This computer is connected to the Internet via the institutional T1 line and each fellow will be provided with a Lahey e-mail address for the duration of employment at Lahey Clinic. Within the fellow's office is housed a comprehensive library of arrhythmia texts and current as well as bound journals of sub-specialty interest not carried in the institutional library.

This document outlines the educational activities and goals or milestones that are intended to guide faculty and fellows in the instructional and evaluative process. The goals are divided into the five major clinical and academic categories that comprise the fellowship: the in-patient service, outpatient setting, electrophysiology laboratory, teaching, and research. In addition, a comprehensive list of subject matter which is expected to be covered during the year is provided: this material will be covered during the course of clinical/procedural experiences, by conference/didactic teaching, or by private reading and research. Finally, a summary of the clinical and administrative roles of all members of the cardiac arrhythmia service is presented in order to provide the fellow with a clear delineation of occupational expectations and responsibilities. The weekly and monthly schedule of activities for the electrophysiology fellow is outlined in the appendix.

1.2: The ACGME Core Competencies and this Curriculum

In July 2001, the Accreditation Council for Graduate Medical Education (ACGME) introduced six newly defined areas of competency which residents and fellows must attain over the course of their training. In this edition of the Cardiac Electrophysiology Curriculum, educational program descriptions for the core activities have been reorganized around these core competencies. In future editions, methods of assessment will be developed and utilized to more completely address the defined competencies. The six competencies are:

1. **Patient Care:** Residents are expected to provide patient care that is compassionate, appropriate and effective for the promotion of health, prevention of illness, treatment of disease and care at the end of life.
    - Gather accurate, essential information from all sources, including medical interviews, physical examination, records, and diagnostic/therapeutic procedures.
    - Make informed recommendations about preventive, diagnostic, and therapeutic options and interventions that are based on clinical judgment, scientific evidence, and patient preferences.
    - Develop, negotiate and implement patient management plans.
    - Perform competently the diagnostic and therapeutic procedures considered essential to the practice of Clinical Cardiac Electrophysiology.
2. **Medical Knowledge:** Residents are expected to demonstrate knowledge of established and evolving biomedical, clinical and social sciences, and demonstrate the application of their knowledge to patient care and education of others.

- Apply an open-minded and analytical approach to acquiring new knowledge.
- Develop clinically applicable knowledge of the basic and clinical sciences that underlie the practice of Clinical Cardiac Electrophysiology.
- Apply this knowledge in developing critical thinking, clinical and technical problem solving, and clinical decision-making skills.
- Access and critically evaluate current medical information and scientific evidence and modify knowledge base accordingly.

3. **Practice-Based Learning and Improvement:** Residents are expected to be able to use scientific methods and evidence to investigate, evaluate, and improve their patient care practices.
   - Identify areas for improvement and implement strategies to improve knowledge, skills, attitudes, and processes of care.
   - Analyze and evaluate practice experiences and implement strategies to continually improve the quality of the practice of Clinical Cardiac Electrophysiology.
   - Develop and maintain a willingness to learn from errors and use errors to improve the system or processes of care.
   - Use information technology or other available methodologies to access and manage information and support patient care decisions and personal education.

4. **Interpersonal Skills and Communication:** Residents are expected to demonstrate interpersonal and communication skills that enable them to establish and maintain professional relationships with patients, families, and other members of health care teams.
   - Provide effective and professional specialist consultation to other physicians and health care professionals and sustain therapeutic and ethically sound professional relationships with patients, their families, and colleagues.
   - Use effective listening, nonverbal, questioning, and narrative skills to communicate with patients and families.
   - Interact with consultants in a respectful and appropriate fashion.
   - Maintain comprehensive, timely, and legible medical records.

5. **Professionalism:** Residents are expected to demonstrate behaviors that reflect a commitment to continuous professional development, ethical practice, an understanding and sensitivity to diversity and a responsible attitude toward their patients, their profession, and society.
   - Demonstrate respect, compassion, integrity, and altruism in their relationships with patients, families, and colleagues.
   - Demonstrate sensitivity and responsiveness to patients and colleagues, including gender, age, culture, religion, sexual preference, socioeconomic status, beliefs, behaviors and disabilities.
   - Adhere to principles of confidentiality, scientific/academic integrity, and informed consent.

- Recognize and identify deficiencies in peer performance.
- Develop a clear understanding of the complex and challenging relationships in Clinical Cardiac Electrophysiology between clinician/providers, hospitals and industry; understand the inherent conflicts of interest in many relationships with industry and its representatives, and develop strategies to ensure clear boundaries that are designed to uncompromisingly prioritize high quality patient care.

6. **Systems-Based Practice:** Residents are expected to demonstrate an understanding of the contexts and systems in which health care is provided, and demonstrate the ability to apply this knowledge to improve and optimize health care.
    - Understand, access, and utilize the institutional resources and providers at Lahey Clinic that necessary to provide optimal care.
    - Understand the limitations and opportunities inherent in various practice types and delivery systems, and develop strategies to optimize care for the individual patient.
    - Given the high costs of many treatments, residents are expected to apply evidence-based, cost-conscious strategies to prevention, diagnosis, and treatment selection in cardiac electrophysiology.
    - Collaborate with other members of the health care team to assist patients in dealing effectively with complex systems and to improve systematic processes of care.

2.1: Principal Teaching/Learning Activities
The following activities within the fellowship program provide learning and teaching opportunities for the trainee in clinical cardiac electrophysiology:

<u>2.2: Direct Patient Care:</u>

The collaborative relationship between attending physician and trainee in the delivery of patient care is at the core of this Program; the provision of high-quality patient care is the fundamental vehicle for teaching and learning of all the required competencies. In the development of educational objectives direct patient care is broadly and somewhat arbitrarily divided into those three loci of care where the particular skills required of the successful sub-specialist in cardiac electrophysiology differ:

- Out-Patient clinic including implantable device follow up clinic (DPC-OP*)
- Hospital, including coronary, medical and surgical intensive care units and the emergency department (DPC-H*)
- Electrophysiology Laboratory (DPC-EPL*)

<u>2.3: Conferences:</u>

Teaching conferences are convened at the institutional, departmental and section level and all contribute to the educational experience of the cardiac electrophysiology trainee.

- Lahey Clinic Resident/Fellow Core Curriculum Lecture Series (CCL*)
- Department of Medicine Grand Rounds (GR*)
- Department of Medicine Resident Lecture Series (RLS*)
- Department of Cardiology Didactic Lecture Series (CDL*)
- Department of Cardiology Morbidity and Mortality Conference (M&M*)
- Department of Cardiology Electrophysiology Conference (EPC*)
- Department of Cardiology and Arrhythmia Service ECG/electrogram teaching conferences (ECG*)
- Department of Cardiology and Arrhythmia Service Journal Club (JC*)
- Department of Cardiology and Arrhythmia Service Case Conference (CC*)
- Arrhythmia Service Didactic Conference (DC*)

3.1: Principal Educational Goals by Relevant Competency

In the tables below, the principal educational goals for all activities that are part of the Cardiac Electrophysiology Residency are indicated for each of the six ACGME competencies. The second column of the table indicates the most relevant principal teaching/learning activity for each goal, using the legend above(*).

<u>3.2: Patient Care</u>

Principal Educational Goals	Learning Activities*
Interview and examine patients more skillfully	DPC-OP, DPC-H
Interpret noninvasive data more skillfully	DPC-OP, DPC-H, EPC, CC, DC
Interpret invasive data more skillfully	DPC-EPL, EPC, CC, DC
Successfully evaluate and manage implanted devices	DPC-OP, DPC-H, DPC-EPL, EPC, CC, DC
Generate and prioritize differential diagnoses	DPC-OP, DPC-H, DPC-EPL, EPC, CC, DC
Develop rational, evidence-based management strategies	DPC-OP, DPC-H, DPC-EPL, EPC, CC, DC

<u>3.3: Medical Knowledge</u>

Principal Educational Goals	Learning Activities*
Expand clinically applicable knowledge base of the basic and clinical sciences underlying the care of patients with cardiac arrhythmias in accordance with the syllabus in Parts 5.1-5.7 of this curriculum	DPC-OP, DPC-H, DPC-EPL, GR, CDL, EPC, ECG, JC, CC, DC
Access and critically evaluate current medical	EPC, ECG, JC, CC

information and scientific evidence relevant to care of the arrhythmia patient	

3.4: Practice-Based Learning and Improvement

Principal Educational Goals	Learning Activities*
Identify and acknowledge gaps in personal knowledge and skills in the care of arrhythmia patients	DPC-OP, DPC-H, DPC-EPL, CC, EPC, ECG
Develop and implement strategies for filling gaps in knowledge and skills	JC, CC, EPC, ECG, DC, CDL, GR

3.5: Interpersonal Skills and Communication

Principal Educational Goals	Learning Activities*
Communicate effectively with patients and families	DPC-H, DPC-OP, DPC-EPL
Communicate effectively with physician colleagues at all levels	DPC-H, DPC-OP, DPC-EPL, CCL
Communicate effectively with all non-physician members of the health care team to assure comprehensive and timely care of arrhythmia patients	DPC-H, DPC-OP, DPC-EPL
Present patient information concisely and clearly, verbally and in writing	DPC-OP, DPC-H, DPC-EPL, EPC, CC, M&M
Teach colleagues effectively	DPC-H, DPC-EPL, RLS, EPC, JC, CC

3.6: Professionalism

Principal Educational Goals	Learning Activities*
Behave professionally toward towards patients, families, colleagues, and all members of the health care team	All
Recognize the substantial pressures in cardiac electrophysiology that create a potential for conflicts of interest and develop strategies for avoidance of impropriety	DPC-EPL, DPC-H, DPC-OP

3.7: Systems-Based Practice

Principal Educational Goals	Learning Activities*
Understand and utilize the multidisciplinary	DPC-H, CCL, M&M

resources necessary to care optimally for patients with cardiac arrhythmias	
Collaborate with other members of the health care team to assure comprehensive patient care	DPC-H, DPC-OP
Use evidence-based, cost-conscious strategies in the care of arrhythmia patients	DPC-H, DPC-OP, DPC-EPL, CCL, GR, EPC, JC, CC, M&M

4.1: Educational Objectives

4.2: In Patient Service
This series of objectives covers all activities performed in the hospital including rounds and continuing care of patients on the arrhythmia service as well as consultative work.

By end of first month:
1. Familiarity with hospital and departmental geography and the procedures for ordering clinical activities.
2. Familiarity with the hospital computer system; ability to find relevant patient data from the clinical information system.
3. Familiarity with the standard pre-procedure evaluation and orders, as well as post-procedure monitoring and follow up for patients undergoing all electrophysiology procedures.

By end of sixth month:
1. Individual performance of clinical consultation for patients admitted with arrhythmias, syncope, or arrhythmia devices requiring evaluation.
2. Ability to obtain, interpret, and synthesize clinical and laboratory data.
3. Ability to succinctly formulate written management plans or advice.
4. Understanding of the indications and contraindications for performance of both noninvasive and invasive diagnostic procedures in patients with cardiac arrhythmias.
5. Understanding of the indications and contraindications for permanent pacemaker implantation.
6. Understanding of the indications and contraindications for defibrillator implantation.
7. Understanding of the indications and contraindications for catheter ablation of arrhythmias.
8. Understanding of the indications for anti-arrhythmic drug therapy; awareness of drug classification, pharmacokinetics and pharmacodynamics as well as important common and uncommon drug interactions. Ability to recognize symptoms, signs, and laboratory evidence of anti-arrhythmic drug toxicity.
9. Ability to teach and provide educational advice in response to questions and concerns raised by the internal medicine and cardiology house-staff regarding the diagnosis and management of patients with cardiac arrhythmias.

4.3: Outpatient Clinic

These objectives apply to the performance of outpatient consultations and follow up visits as well as to the pacemaker and defibrillator clinics.

By end of the first month:
1. Familiarity with the clinic procedures and geography including the location of the pacemaker/ICD programmers, ECG machines and resuscitation equipment/drugs.
2. Ability to interrogate all commonly used pacemakers and defibrillators using the standard programmer interfaces.
3. Observation of threshold measurement and troubleshooting of pacemakers and defibrillators (at least one example of all the frequently used devices).
4. Observation of at least two tilt table tests.

By end of the third month:
1. Ability to validate and interpret T wave alternans exercise studies
2. Ability to interpret transtelephonic electrocardiograms of pacemaker patients regarding the native rhythm and presence or absence of capture. Understanding of the common criteria for power source depletion.
3. Ability to interpret transtelephonically transmitted event recordings from patients with symptoms thought to be due to arrhythmia.
4. Understanding of the normal healing process in the femoral area after invasive procedures. Ability to discern when puncture sites are abnormal due to infection or hematoma.
5. Ability to independently perform tilt table tests and to document data from such testing.

By end of the sixth month:
1. Understanding of the normal wound healing process after pacemaker and defibrillator surgery. Ability to discern when wounds are abnormal due to infection or hematoma.
2. Ability to interpret post ablation electrocardiograms for evidence of prolonged AV conduction, pre-excitation, or bundle branch block.
3. Ability to independently interpret telemetry data and measure pacemaker pacing and sensing thresholds.
4. Ability to interpret radiologic studies of patients with pacemakers and/or defibrillators.

By end of the ninth month:
1. Ability to program appropriate prescription changes to pacemakers and defibrillators based upon patient symptoms, or abnormal telemetered/measured data.

<u>4.4: Electrophysiology Laboratory</u>

These objectives apply to all procedures performed in the laboratory, most commonly diagnostic and interventional studies, pacemaker and defibrillator implantations.

By the end of the first month:
1. Understanding of the methods and locations of vascular access used for diagnostic

and interventional catheter procedures.
2. Understanding of the normal radiologic appearances of appropriately placed diagnostic catheters in the right ventricle (apex and outflow tract), right atrium (including appendage), coronary sinus, and His bundle position.
3. Understanding of the methodology of electrogram display including principles of filtering and amplification.
4. Understanding of the principles of programmed stimulation and the protocols used in the laboratory.
5. Knowledge of the location and use of emergency resuscitation equipment in the electrophysiology laboratory including defibrillators, emergency drugs, pericardiocentesis and pleural drainage equipment.
6. Ability to use the pacing systems analyzer to measure sensing and pacing characteristics of implanted pacing leads.
7. Understanding of the anatomic and radiologic landmarks used in permanent pacemaker and transvenous defibrillator lead placement.
8. Familiarity with the modes of operation of all pacemaker and defibrillator programmers and external testing equipment.

By the end of the third month:
1. Ability to use the recording equipment to acquire and label intracardiac electrograms.
2. Ability to use the programmable stimulator for routine pacing protocols used in the commonly performed invasive procedures.
3. Ability to routinely place sheaths.
4. Ability to routinely place catheters in right atrium, right ventricle, and His position.
5. Understanding of normal and abnormal electrogram recordings from the right atrium, right ventricle, His position, and coronary sinus.
6. Ability to interpret the intracardiac recordings from common supraventricular and ventricular arrhythmias.
7. Detailed understanding of the cardiac anatomy and fluoroscopic appearances of the usual target sites for catheters ablation: the mitral and tricuspid annuli.
8. Familiarity with the operation of radiofrequency lesion generator, and an ability to use the equipment to deliver RF energy. Awareness of importance of temperature and impedance monitoring and criteria for halting energy delivery.
9. Familiarity with the handling characteristics of steerable interventional catheters and ability to follow instructions in placing a catheter in appropriate intracardiac location for ablation.
10. Understanding of the surgical techniques used to locate, isolate and tie the cephalic vein for pacemaker and defibrillator surgery.
11. Familiarity with the handling characteristics of pacemaker and defibrillator leads, and the techniques used to place these leads in appropriate intracardiac positions.
12. Ability to program external testing equipment used for implantation support in pacemaker and defibrillator procedures; ability to perform sensing, pacing, and defibrillation threshold assessments using the commonly employed equipment.

By the end of the sixth month:
1. Ability to routinely place a catheter in the coronary sinus.
2. Ability to interpret and use data from diagnostic studies in patients with syncope to guide further diagnostic and/or therapeutic recommendations.
3. Ability to interpret and use data from diagnostic studies in patients with ventricular arrhythmias to determine therapeutic decisions.
4. Ability to interpret and use data from diagnostic studies in patients with supraventricular arrhythmias in order to guide placement of the ablation catheter.
5. Ability to use recorded electrograms from ablation catheters to determine appropriate placement for RF energy delivery.
6. Ability to determine when and which autonomic and other pharmacologic drug interventions are appropriate during diagnostic and interventional procedures.
7. Ability to perform the necessary surgery, and interpret testing data for pectoral permanent pacemaker implantation and pulse generator replacement procedures.

By the end of the ninth month:
1. Ability to troubleshoot problems in the laboratory related to signal acquisition and recording as well as pacing.
2. Ability to select catheter(s) and perform an ablation procedure targeted to accessory pathway or AV nodal region with minimal supervision.
3. Ability to perform the necessary surgery, and interpret testing data for pectoral defibrillator implantation and pulse generator replacement procedures.
4. Ability to perform necessary surgery and interpret testing data for abdominal defibrillator pulse generator procedures.

4.5: Teaching/Conferences

These objectives refer to the electrophysiology fellow's obligations to attend and periodically present material to conferences held both in the cardiac department and the department of medicine.

1. After the first month, presentation of weekly case presentation or journal club with material selected in conjunction with the program director. Cases will be selected in conjunction with the staff physician attending in the electrophysiology laboratory during the previous week.
2. Attendance at all cardiac department conferences held on Tuesday and Wednesday at noon, including cardiac catheterization, echocardiography, ECG, and morbidity/mortality conferences. After the first month the cardiac electrophysiology fellow will present case(s) monthly at one of these sessions devoted to cardiac pacing and electrophysiology.
3. Attendance at Medical Grand Rounds held at 8.00am Fridays.
4. Attendance at monthly conferences/lectures in medical ethics.
5. Attendance at monthly core curriculum lectures organized by the Department of Medical Education.
6. In the second sixth months of the year, at least two lunchtime lectures to medical

house-staff will be presented by the electrophysiology fellow. The topics will be chosen in conjunction with the program director in internal medicine/chief medical resident and will cover the field of cardiac pacing and electrophysiology at a level appropriate for medical residents.
7. The electrophysiology fellow may be asked to participate in the medical student ECG teaching conference which is a continuous course held throughout the year.

4.6: Research

These objectives cover the research component of the electrophysiology fellowship. It is expected that each fellow will work with a faculty preceptor to develop and complete a study during the fellowship year. Completion of a study is intended to include presentation at regional or national meetings and submission of a manuscript for publication.

1. By the end of the first month it is expected that a faculty preceptor and suitable project will have been selected. A written protocol combined with a brief literature review will have been completed.
2. By the end of the third month it is expected that data collection will be ongoing and that any technical problems will have been resolved.
3. By the end of the ninth month data collection will have been completed and analysis initiated.
4. By the end of the year an abstract will have been written and submitted for presentation to a national meeting. Work on a manuscript for publication will have been substantially completed.

5.1: Core Curriculum Subject Matter

Completion of satisfactory training in Clinical Cardiac Electrophysiology will entail educational experiences that expose the trainee to the following topics. These are considered to be essential core knowledge for the successful specialist, but it is understood that in this dynamic field the syllabus will require constant revision with changes in both content and emphasis. A recently published summary of teaching objectives in cardiac electrophysiology which includes a pertinent bibliography is provided (6.1).

5.2: Basic Ionic, Cellular and Autonomic Cardiac Electrophysiology

Pharmacology of the cardiac sodium, potassium and calcium channels
The cellular mechanisms of discontinuous atrioventricular nodal recovery and the gap phenomenon
Modulation of the heartbeat by the vagus nerve
Cardiac vagal activity, myocardial ischemia, and sudden death
Autonomic modulation of cardiac arrhythmias
Mechanisms of ischemia-induced arrhythmias
Arrhythmogenic effects of antiarrhythmic drugs
Anisotropic reentry as a cause of ventricular tachyarrhythmias in myocardial infarction

Mechanisms of sudden cardiac death
Activation patterns during ventricular fibrillation
Normal and abnormal activation of the atrium
Reentrant mechanisms underlying atrial fibrillation
Reentrant mechanisms in ventricular arrhythmias
Stretch-activated arrhythmias

5.3: Clinical Arrhythmias: Mechanisms, Clinical Features, and Management
Sinus node reentry and atrial tachycardias
Typical and atypical atrioventricular nodal (junctional) reentrant tachycardia
Atrioventricular reentry and variants: mechanisms, clinical features, and management
Anatomical and physiological substrate for antidromic reciprocating tachycardia
Atrial flutter: mechanisms, clinical features, and management
Atrial fibrillation
Paroxysmal junctional and fascicular tachycardia in adults
Interactions between the autonomic nervous system and supraventricular tachycardia
Life-threatening ventricular arrhythmias: the link between epidemiology and pathophysiology
Ventricular tachycardias in the setting of coronary artery disease
Dilated cardiomyopathy: ventricular arrhythmias and sudden death
Arrhythmogenic right ventricular dysplasia
Hypertrophic cardiomyopathy
Ventricular tachycardia in structurally normal hearts
The long QT, Brugada, and other genetic arrhythmia syndromes
Sudden cardiac death
Mitral valve prolapse
Arrhythmias following surgery for congenital heart disease
Ventricular arrhythmias in heart failure
Bundle branch reentry: mechanisms, diagnosis, and treatment
Torsades de pointes
Repetitive monomorphic ventricular tachycardia
Verapamil-responsive ventricular tachycardia
Accelerated idioventricular rhythm, bidirectional ventricular tachycardia
Ventricular fibrillation

5.4: Electrocardiographic Recognition
Normal and abnormal intervals
Atrioventricular block and dissociation
Parasystole
Electrocardiographic manifestations of exit block
Wide QRS complex tachycardia: electrophysiological mechanisms and electrocardiographic features
Electrocardiographic localization of accessory pathways

5.5: Diagnostic Evaluation
Assessment of the patient with a cardiac arrhythmia
Exercise-Induced ventricular arrhythmias
Ambulatory (Holter) electrocardiography recordings
Signal-averaged electrocardiography
Transesophageal recording
Rationale and methodology of head-up tilt table testing for evaluation of syncope
Spectral analysis of R-R variability to evaluate autonomic physiology and to predict outcomes
Clinical value and limitations of cardiac electrophysiological studies
Principles or electrogram recording and filtering
Principles of cardiac stimulation
Principles of radiation safety
Principles of transmissible disease prevention in laboratory setting
Activation mapping: unipolar versus bipolar recording
Pace-mapping
Entrainment mapping
Techniques for localization and radiofrequency catheter ablation of accessory pathways
Catheter mapping of ventricular tachycardia
Electroanatomic and non-contact mapping techniques
Monophasic action potential recording
Assessment of the role of the autonomic nervous system in tachycardias

5.6: Clinical Syndromes
The Wolff-Parkinson-White syndrome
Sinus node dysfunction: pathophysiology, clinical features, evaluation, and treatment
Evaluation of the patient with unexplained syncope
Adult/pediatric arrhythmias: similarities and differences
The effects of gender on cardiac electrophysiology and arrhythmias
Role of cardiac electrophysiology in management of heart failure

5.7: Therapy: Pharmacologic, Electrical, and Ablative
The classification of antiarrhythmic drugs
Pharmacokinetics, pharmacodynamics, and pharmacogenetics
Class I antiarrhythmic drugs
Beta-blockers and calcium channel blockers as antiarrhythmics
Class III agents: amiodarone, dofetilide, and sotalol
Adenosine
New antiarrhythmic drugs
Pharmacologically controlling arrhythmias: to delay conduction or to prolong refractoriness
External direct current cardioversion-defibrillation
Cardiac pacing: hemodynamic, electrophysiological, and clinical considerations in selecting the pacemaker

Theory and practice of cardiac resynchronization
Electrical events associated with arrhythmia initiation and stimulation techniques for arrhythmia prevention
Current trends in the implantable cardioverter-defibrillator
Surgical techniques for implantation of the implantable cardioverter-defibrillator
Long-term follow-up and clinical results of implantable cardioverter-defibrillators
Antiarrhythmic drug - implantable cardioverter-defibrillator interactions
Energy sources for catheter ablation
The biophysics and pathophysiology of lesion formation during radiofrequency ablation
Catheter ablation of the atrioventricular node for treatment of supraventricular arrhythmias
Radiofrequency catheter ablation of atrial tachycardia and flutter
Catheter ablation of atrioventricular nodal reentrant tachycardia
Catheter ablation of atrioventricular reentrant tachycardias
The atrial approach to radiofrequency catheter ablation
Catheter ablation of ventricular tachycardia in patients with coronary heart disease
Ablation of ventricular tachycardia in patients with structurally normal hearts
Catheter ablation in pediatric patients
Chemical ablative therapy for arrhythmias
Surgery for arrhythmias

6.1 Recommended Educational Resources

- Textbooks
  - Zipes and Jalife: Cardiac Electrophysiology from Cell to Bedside. WB Saunders , 2000
  - Josephson: Clinical Cardiac Electrophysiology. Lippincott, 2002
- Journals
  - Pacing and Cardiac Electrophysiology (PACE)
  - Journal of Cardiovascular Electrophysiology (JCE)
  - Heart Rhythm
- Manuscripts
  - Link M, Antzelevitch C, Waldo A, et al: *Clinical cardiac electrophysiology teaching objectives for the new millennium.* J Cardiovasc Electrophysiol; 2001 (12): 1433-1443
- Web links
  - http://www.hrsonline.org/
  - www.cardiosource.com
  - http://www.acgme.org/acWebsite/positionPapers/pp_GMEGuide.pdf

7.1: Evaluation Methods

The Lahey Clinic cardiac electrophysiology program is small in terms of both trainees and faculty; this intimate setting allows for continuous supervision and evaluation of performance; formal evaluations of fellows are completed at least quarterly by all faculty using a standard written instrument; in addition, standardized checklists of procedural

competency are administered periodically during common laboratory procedures. The program director meets regularly with the fellow to provide and obtain feedback on performance. Discussions with both faculty and support staff (physician assistants, nurses, secretaries and clinic assistants) also provide valuable feedback to the program director regarding the fellow's performance. It is planned to initiate on-line evaluations in due course using specifically designed tools for procedural specialties in which the fellow's performance and progression during training can be monitored by direct input from program director, faculty and support staff. During the 2005-6 academic year it is expected that on-line "360° assessments" of the professionalism and communication competencies will be established in collaboration with the Cardiovascular Disease Program Director. Furthermore, formal evaluation of the program by the physician(s) in training will be required at the end of the program although such feedback is continuously sought during the academic year.

8.1: Administrative Roles And Responsibilities Of Personnel In The Cardiac Arrhythmia Service

There are five electrophysiology physicians and three FTE mid-level practitioners providing clinical care to patients of the cardiac arrhythmia service of Lahey Clinic. Staff physicians rotate on a weekly basis through three areas of clinical responsibility: invasive laboratory procedures, ward patient care, and out patient clinic care. Service meetings and conferences are held at least twice weekly to coordinate care and provide teaching to fellows.

8.2: Chain of Command

Physicians-in-training function under the supervision of Lahey Clinic staff physicians at all times. The Program Director of each training program is responsible for the overall performance and supervision of the trainees in that program. Faculty members responsible for supervising participation in patient care by physicians in training shall be medical staff members in good standing, with relevant clinical privileges at Lahey Clinic. No Lahey Clinic medical staff member, whether he or she is a member of the teaching faculty, shall leave patients in the charge of physicians in training as primary coverage. In the case of clinical consultations, no Lahey Clinic medical staff member called to consult shall leave primary responsibility for the consultation up to a physician in training. The extent of participation of physicians in training in the care of a patient shall be disclosed and clarified to the patient and/or family members. Each patient's attending physician and consulting physicians shall coordinate with the responsible faculty physician in supervising patient evaluations, treatments and procedures provided or performed by physicians in training. In compiling performance evaluation/quality improvement data from patient encounters where physicians in training have participated in patient care, the supervising faculty physician shall be responsible for the activities of the physician in training and all information, conclusions and improvement data shared with the supervising Lahey Clinic faculty member.

8.3: Ward Service

Staff physicians make daily rounds with a physician assistant and/or an electrophysiology fellow, and assume individual responsibility for the clinical care of in-patients on the arrhythmia service; the electrophysiologist assigned to "Lab 1" on a weekly basis coordinates the admission and discharge of all transferred in-patients with their referring physicians. This in-patient physician sees all consultations in conjunction with an electrophysiology fellow and schedules procedures in the laboratory as indicated. In order to optimize the educational and clinical continuity of care, the fellow performing the consultation should ordinarily be the first operator for any subsequent procedure for each patient and it is the fellow's responsibility to indicate such a continuity relationship on the EP laboratory schedule. Mid-level practitioners, acting under the supervision of the ward attending physician, are responsible for admission and discharge orders as well as for documenting admission and follow up notes in the medical record. In addition, mid-level practitioners dictate discharge summaries for editing and signature by the staff physician. The staff physician is responsible for contacting referring physicians and ensuring that follow up arrangements for discharged patients are satisfactory. Patients on the electrophysiology service who are in an intensive care setting all have house-staff coverage, and an electrophysiology fellow, in conjunction with the attending physician, will be responsible for liaison regarding the daily care of these patients.

8.4: Invasive Service

Two staff electrophysiologists are assigned to the laboratories on a rotating weekly basis; the "Lab 1" physician coordinates activities in conjunction with the "Lab 2"

physician, laboratory nursing staff and fellows but has final authority to make decisions regarding scheduling of cases. The laboratory staff physicians supervise all invasive procedures and are responsible for the care of all patients undergoing procedures in the electrophysiology laboratory. Generally the "Lab 1" physician performs procedures for hospitalized patients transferred to Lahey Clinic or seen in consultation; the "Lab 2" physician generally performs procedures on elective cases booked from the out-patient setting. The laboratory physicians provide teaching and guidance for the fellows on the interpretation of electrophysiologic data derived from all procedures performed in the laboratory. A cardiac electrophysiology fellow is first operator for all electrophysiology laboratory procedures in conjunction with the laboratory staff physician. Fellows are expected to assign themselves to *all* cases in the laboratory based on the schedule drawn up 24 hours in advance and upon their previous contact with patients booked for procedures. This assignment should be clearly indicated on the board in the laboratory so that nursing staff are aware of who to call for all procedures. Fellows generally see all patients scheduled for laboratory procedures prior to arrival in the laboratory and explain to the patient the rationale for the procedure as well as all of the risks involved. As part of this pre-procedure evaluation fellows ensure that the appropriate orders are written and consent form signed. After all laboratory procedures the fellow writes post-procedure orders, (*and* admitting orders if necessary), and completes the computerized report under the supervision of the staff physician. After all laboratory procedures the fellow visits the patient on the floor and ensures that no complications referable to the procedure have occurred. After pacemaker implantation the implanting fellow also performs a pacemaker system evaluation in conjunction with either the staff physician or mid-level practitioners. After all procedures in which subclavian or jugular vessels have been cannulated, and after all pacemaker and transvenous defibrillator implants the fellow who performed the procedure personally views the post-procedure chest radiograph to exclude relevant abnormalities.

8.5: Out-Patient Service

The staff physician responsible for the out-patient clinic sees all out-patient consults for the arrhythmia service; in addition s/he will supervise non-invasive testing (signal averaging and tilt table testing) as well as the pacemaker and ICD clinics. Pacemaker and defibrillator clinics are held daily; fellows attend device clinics when no laboratory procedures are scheduled, and have a dedicated arrhythmia consultation and continuity clinic weekly for one half-day session. Fellows perform interrogation and troubleshooting of all pacemakers and defibrillators using the standard programming and ECG tools available as well as occasional radiography. The findings and management plans are discussed with the out patient staff physician. Fellows also see urgent consults and perform out-patient pre-operative evaluations under the supervision of the staff physician.

8.6: Assignment of Patients

All in-patients under the care of the three staff electrophysiologists are considered "teaching" patients in relation to the arrhythmia service fellows. These patients,

combined with those consulted upon by the staff electrophysiologists, constitute the in-patient arrhythmia service and all are assigned to the electrophysiology fellowship program for teaching purposes. Patients located in the intensive care units or admitted via the emergency department will typically be assigned to the medical residency house-staff and therefore will not be followed by mid-level practitioners. However, electrophysiology fellows are expected to be familiar with all such patients and to be closely involved in their management.

8.7: Orders

Fellows and physician assistants may write orders in the in-patient or out-patient records of all patients under the care of the three staff electrophysiologists. These orders do not require co-signature of the staff physician but all orders that deviate from standard pre-printed procedural format require discussion with the relevant staff physician.

8.8: Call Responsibilities

The ACGME Policy on Resident Duty Hours (effective July 2003) is available at www.acgme.org; the Lahey Clinic residency in Clinical Cardiac Electrophysiology adheres to this policy and generally far exceeds its requirements. The fellows and three staff physicians assume an equal share of week-end call for the arrhythmia service so that the fellow is on call on average one week-end in seven; when a fellow is on call there will be a designated staff electrophysiologist available to provide support for clinical or procedural management as appropriate. Fellows will not be expected to assume any on call responsibilities during the working week except for calls related to hospitalized patients that they have operated upon or seen in consultation; this responsibility ensures continuity of both the care and education experience. Fellows will not be expected to be resident on call but will be available by telephone from within 30 minutes of the hospital at all times when on call; a mobile phone will be provided. On call responsibilities include daily rounds on all arrhythmia service patients as well as consulting patients on other services. In addition, the on call physician is responsible for making the arrangements for the performance of all necessary invasive or non-invasive procedures related to arrhythmia investigation or management. Should the routine and emergency weekend call responsibilities lead to an excess of hospital hours worked in any week (>80 hours) the designated staff electrophysiologist will assume call responsibility. In order to document duty hours all fellows are required to keep a record of time spent in the hospital during randomly sampled weeks of the year.

8.9: Vacation and professional leave

Each fellow receives fifteen (15) days of vacation in each calendar year, as indicated in the House Staff Manual and the fellowship agreement. Weekends and clinic holidays are not charged as vacation time. Fellows must schedule all vacation and professional leave in conjunction with, and with the assent of, the program director. Vacation time must be used during the term of the fellowship program since unused vacation cannot be sold back. Vacation time allocated during a partial calendar year will be allocated on

a pro-rated basis. All on-site CME courses sponsored by Lahey Clinic Foundation are open to Lahey Clinic residents and fellows on a space-available basis with the approval of the course instructor and the program director. Registration fees are waived for residents and fellows. Any paper or poster presented at a local, national or regional society meeting will be supported financially by Lahey Clinic, and in addition the electrophysiology program strongly encourages the attendance of the fellow(s) at one major cardiac/electrophysiology meeting per year. Full financial support is provided for such attendance. Usually the fellow(s) will attend the NASPE meeting, but the ACC or AHA meetings also qualify for financial support.

8.10: Procedure Log and Fellowship Portfolio

The cardiac electrophysiology fellow is responsible for maintaining a personal log of all procedures performed in and out of the laboratory; such procedures should include both invasive and noninvasive testing. Collected data should include patient name and medical record number, date and type of procedure, indication(s), complications, and name of supervising faculty physician. In addition, fellows are responsible for compiling a portfolio of their written material produced during the fellowship. This includes copies of inpatient and outpatient consultation notes and reports of invasive and noninvasive procedures, as well as all teaching materials prepared for departmental and institutional conferences. At the end of the fellowship, this complete portfolio becomes part of the fellow's permanent record, from which future credentialing recommendations are made. Therefore, this log should be complete and accurate. It will be evaluated by the program director who will certify its authenticity.

9.1: Acknowledgements

This curriculum is a living document and will undergo annual revision. In the production of this edition I would like to thank my colleagues in the Department of Cardiology (particularly Sherif Labib and Roy John), the Graduate Medical Education Committee (David Schoetz), and the Program Director in Internal Medicine at Lahey Clinic (Gerry Orfanos) for advice and feedback during the development of this document. In addition, I wish to acknowledge the use of ideas and text derived from the ACGME and the University of Rochester School of Medicine and Dentistry Internal Medicine Residency Educational Program Description written by Donald Bordley, MD. Despite these (and other) forms of assistance I am solely responsible for any errors or omissions in this document.

10.1: Document History

Completed original: 11/25/98
Rev2: 3/18/00
Rev3: 11/11/02
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Rev4.1: 6/8/04
Rev5: 7/1/05

Appendix

Cardiac Electrophysiology Fellow
Weekly and Monthly Schedule of Educational Activities

Clinical Cardiac Electrophysiology Fellows
Weekly Schedule

<table>
<tr><th></th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th></tr>
<tr><td>0730</td><td>Service Rounds</td><td>CCEP Resident Conference</td><td>Core Curriculum Lecture (Monthly: CCL)</td><td>Lecture (CDL)</td><td>Medical Grand Rounds (GR)</td></tr>
<tr><td>0900 - 1200</td><td rowspan="3">Lab/Rounds/Consults (DPC-H/EPL)</td><td>Consult/Continuity Clinic (DPC-OP)</td><td>Lab/Rounds/Consults (DPC-H/EPL)</td><td>Consult/Continuity Clinic (DPC-OP)</td><td rowspan="3">Lab/Rounds/Consults (DPC-H/EPL)</td></tr>
<tr><td>1200</td><td>Cardiology Conference</td><td>Cardiology Conference</td><td rowspan="2">Lab/Rounds/Consults (DPC-H/EPL)</td></tr>
<tr><td>1300 - 1800</td><td>Lab/Rounds/Consults (DPC-H/EPL)</td><td>Research</td></tr>
</table>

Monthly Conference Schedule

Wee k	Tuesday 7:30am	Tuesday 12:00pm	Wednesday 12:00pm
1st	Clinical Case Discussion (CC)/ Didactic Conference (DC)	ECG Unknowns (ECG)	Interventional
2nd	Journal Club (JC)/ Didactic Conference (DC)	Journal Club (JC)	Morbidity and Mortality (M&M)
3rd	Clinical Case Discussion (CC)/ Didactic Conference (DC)	Echocardiography	Interventional
4th	Unknown Tracings (ECG)/ Didactic Conference (DC)	Fellow Presentation (CDL)	EP Service (EPC)
5th	Clinical Case Discussion (CC)/ Didactic Conference (DC)	Research/Open	Research

Legend:

- DPC-OP: Out-Patient clinic including implantable device follow up clinic
- DPC-H/EPL: Electrophysiology Laboratory and Hospital, including coronary, medical and surgical intensive care units and the emergency department
- CCL: Lahey Clinic Resident/Fellow Core Curriculum Lecture Series
- GR: Department of Medicine Grand Rounds
- RLS: Department of Medicine Resident Lecture Series
- CDL: Department of Cardiology Didactic Lecture Series
- M&M: Department of Cardiology Morbidity and Mortality Conference
- EPC: Department of Cardiology Electrophysiology Conference
- ECG: Department of Cardiology and Arrhythmia Service ECG/electrogram teaching conferences
- JC: Department of Cardiology and Arrhythmia Service Journal Club
- CC: Department of Cardiology and Arrhythmia Service Case Conference

- DC: Arrhythmia Service Didactic Conference