I. Introduction

All cardiology training must be carried out in institutions in which the opportunity to participate in research is available. The training site should be one that will provide an atmosphere of intellectual inquiry. It is highly desirable that every cardiovascular trainee participate in research. Cardiology is a dynamic clinical field where rapid transfer of knowledge from basic and clinical research to clinical care has occurred. This pattern will only accelerate in the future. Cardiovascular research is defined in the broadest terms possible because recent history makes it abundantly clear that advances in the care of patients with cardiovascular disease have come from diverse areas of medical science. If the clinical cardiologist is to maintain clinical competence and improve clinical knowledge in step with the progress of the field, it is crucial that he or she thoroughly understands the concepts, methods and pitfalls of research. Every trainee is encouraged to have direct involvement in the practical aspects of research, with emphasis on literature review, data analysis and logical deduction. Those trainees contemplating a career in investigative cardiology bear a special responsibility to prepare for research. The future of the field with regard to both knowledge and education is in their hands. They should take research training as seriously as they do clinical training.

II. General Standards

A. The training institution must have staff and facilities for research. Opportunities for research for the trainees should be available not only within the clinical Cardiovascular Division, but also within the basic biomedical science departments of the institution. Optimally, cardiovascular training should be carried out in a university teaching hospital or similar institution. Where this is not feasible, an active ongoing affiliation with a university is essential.

B. Individual trainees should have, before their appointment, appropriate preparation in the biologic and physical sciences basic to medicine. If additional course work is desirable and appropriate, it should be available, and trainees should be encouraged to avail themselves of it.

C. Faculty of the training program must include several individuals with proven skill as investigators, demonstrated by published original research in peer-reviewed journals. The critical mass of the faculty requires several cardiovascular investigators, not all of whom need to be clinical cardiologists. In general, there should be no more than one trainee per full-time staff member for research training. At least one full-time faculty member from each training program should have demonstrated skill as a clinical investigator.

III. Content of Training Program

A. Types of research. Research may either involve clinical studies or be at the bench. In general, prospective investigations are preferable to retrospective reviews.

B. Clinical investigation. This must be carried out under the supervision of a clinical specialist and according to the institutional rules for patient protection. It must be recognized that clinical research is difficult because of the complexity of achieving valid scientific conclusions while working with a diverse population and while simultaneously protecting the interests of each patient.

C. Components of research. The trainee should participate in at least the following areas:

1. Literature study, to ascertain the exact state of knowledge before undertaking new investigation.
2. Formulation of hypothesis and specific goals, ensuring that the hypothesis is testable and that the goals are achievable.
3. Development of the research plan and the protocol including, where appropriate, informed consent and protection of privacy, data collection modes, full description of procedures and institutional approval of human investigation.
4. Development of analytic methods or procedural skills, as required.
5. Data collection, including preparation of routine data forms.
6. Data analysis, especially the handling of artifacts, missing data, outliers and statistical inference.
7. Presentation of results, preferably both oral and written, emphasizing that no investigation is complete until it is reported in peer-reviewed literature.
8. Risk-benefit analysis, regarding both patient (subject) individual risk and benefit, and societal risk-benefit.
9. Recruitment of subjects, including patients and, where appropriate, their families.

In the case of multiple center clinical trials, participation in the full range of special activities outlined above is required.

It is optional for the trainee to participate in the preparation of documents leading to financial and technical resources required for the study.

D. Advanced training for individuals considering entering investigative cardiology. These trainees bear a special responsibility for preparing carefully in research because it will be an integral part of their continuing career professional activities. Some trainees will have obtained thorough research preparation in MD-PhD combined degree programs, but may lack the special skills involved in clinical research or certain tools that are appropriate to their personal research goals. These may be obtained in a postdoctoral research fellowship experience or as part of the cardiology traineeship.

For full-time training, the trainee should optimally enter the laboratory of a productive and active scientist in any institution in the world (not necessarily where he is obtaining direct training).

Trainees who aim for a career in investigative cardiology but who have not had the opportunity to obtain a PhD or equivalent training at the time they begin their cardiology traineeships, should have the opportunity and be encouraged to obtain the necessary basic science course work and laboratory experience necessary for a productive research career. Current models of this type of training include the American Heart Association clinician scientist program and the National Heart, Lung, and Blood Institute program for clinical scientists and physician scientists.

E. Duration of training. For the trainee whose goal is investigative cardiology, a minimal period of 1 or more years, in which at least 75% of time is devoted to research, is required, in addition to the minimal core of 24 months of clinical training. For the trainee whose goal is the practice of clinical cardiology, up to 12 months of clinical research experience may be included in the minimal 36 month training period.

F. Teaching and manuscript review. It is desirable that the trainee also have the opportunity to be introduced to the elements of pedagogy, because almost all academic cardiologists devote a significant amount of time to teaching. It is also useful to provide opportunities for the critical review of published manuscripts.

G. Compensation. Compensation during the often prolonged period of research training should be sufficient to allow a full-time commitment to this training.

IV. Evaluation

A. Subjective ongoing evaluation by the research sponsor. This is the principal method for judging the trainee’s progress and skills in this area of training.

B. Publication. Trainees should be encouraged to publish substantive results, thereby providing an evaluation by peer-reviewed journals.

C. Dissertation and examination. Some individuals among those preparing for investigative careers in cardiology will obtain a PhD, and they will have the usual preliminary examination and dissertation with its oral defense before a committee of qualified investigators.

The use of an external examiner (from outside one’s own institution) is an excellent device to avoid bias and to promote the trainee’s career. Those not obtaining a formal PhD degree may benefit from a similar procedure.

V. Flexibility

It must be appreciated that the education of future investigative cardiologists is a continuing process, and that they usually remain in an educational institution, where they are immersed in clinical cardiology. They often have unique demands which may require altering the sequence and exposure of clinical training, consistent with their prior clinical experience. Therefore, the program director should be afforded latitude in the assignment of responsibilities for the 3 years of training, while guaranteeing full clinical competence. Programs that provide less than the normal minimum of 36 months of clinical training should be reserved for that minority of trainees who plan a career in academic cardiology in which they will be full-time faculty members of a division or section of cardiology in a medical school.

In special instances, some of the clinical skills ordinarily obtained during the 24 months of core clinical training may be acquired during prior training or during clinically related research, thereby providing additional flexibility for the training of the future investigative cardiologist.

VI. Summary

It is vital to the future intellectual health of cardiovascular medicine and the welfare of patients with cardiovascular disease that all future cardiologists be familiar with the principles and tools of research. Training in research requires the intense involvement of productive and established investigators. Those trainees preparing for a career in investigative cardiology require a carefully developed but flexible educational plan that will permit them to be successful in their research careers over an extended period.