



PART I

Principles and Techniques

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Interventional Cardiology Training

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Introduction

The treatment of coronary artery disease has undergone rapid evolution, with many groundbreaking innovations introduced in the last years. Angioplasty is now the first option in the acute phase of myocardial infarction, allows rapid control and early discharge of patients with acute coronary syndromes, and has eroded the prevalent use of bypass surgery in stable angina and silent ischemia. The drastic reduction of restenosis observed with the use of drug eluting stents makes percutaneous revascularization a viable option in complex lesions, including multivessel and left main disease, with ongoing clinical trials of comparison with surgery. Interventional cardiology has expanded its field of application from coronary arteries to structural heart disease and other degenerative atherosclerotic changes such as peripheral artery disease. If laser and directional atherectomy have almost disappeared from the therapeutic armamentarium, other devices such as Rotablator, cutting balloon, filters, and thromboaspiration devices have become a welcome addition in selected cases as preparation to balloon dilatation and stent implantation. Aspirin and heparin were the only options available 15 years ago and are now complemented or substituted by a variety of antiplatelet and antithrombin agents. Another important

change transforming the practice of interventional cardiology has been the increasing pressure of healthcare systems, forcing interventionalists to use strict interpretation of guidelines for indications, meticulously document procedures and complications in databases open to review from health providers and the general public, acquire management skills to optimize resource utilization, motivate and enhance performance of the team, build stable referral networks.

Specific mandatory training is implemented in few countries around the world. With these few exceptions, all cardiologists but also many other medical specialists (radiologists, cardiac and vascular surgeons) are legally entitled to perform percutaneous interventional procedures after successful completion of training in their main specialty without any specific knowledge and experience in the interventional field. In this chapter, the different reality of interventional training in Europe and the United States is examined to help Fellows understand the similarities and differences and to stimulate growth and improvement on both sides of the Atlantic.

Principles of Medical Training Applied to Interventional Cardiology

As for most doctors, the three cornerstones of the training required for a successful interventionalist are knowledge, professional skills and professionalism. The most knowledgeable cardiologist with a complete background spanning from pathophysiology

of coronary artery disease to the results of the most recent trials will be unable to work safely if s/he has not achieved sufficient practical experience of a variety of procedures, assisted and coached by qualified supervisors. Similarly, a physician combining good theoretical knowledge and hands-on experience can still be inefficient and dangerous if s/he does not use in his/her practice respect and human compassion towards his/her patients and does not have the ability to select and motivate his/her team. Training in interventional cardiology must pay attention to these three complementary essential aspects of the education process and must develop reliable methods of assessment to certify the progress made and indicate the additional steps required to become an independent professional. As the undergraduate and postgraduate medical education is different in the various countries also the curriculum of Interventional Cardiology training must adapt to the different background which explains differences among countries. In this chapter we limited our observations to Europe and the United States.

The State of Interventional Cardiology Training in Europe

The training of specialists in interventional cardiology is not formally regulated in any European countries. Most countries, however, offer a period of one to two years' training in interventional cardiology and the appointment of cardiologists expected to carry out angioplasties and other interventional procedures is in practice restricted at a level of interviews/local credentials required by hospitals to candidates who prove they have successfully completed this training. Still, no official certificates with binding legal value are issued. The official approval of a new Specialty called Interventional Cardiology requires a direct decision of the National Governments since this legislation is demanded to individual countries. The European Community only checks compatibility with the principles governing the community of member states. One such principle is the promotion of free movement of workers, including professionals. It is understandable, therefore, that the European Commission, the Government of the Union, seeks advice from a body representing all

the Medical Colleges of the Member states, called UEMS (European Union of Medical Specialists). This supernational representation has allowed in the past a radical review of the denomination and duration of training in the different post-graduate medical Specialty areas. The complexity of the process required, involving the consultation of all the Departments of Health and Education, Universities and Medical Colleges, is one of the factors explaining the reluctance to introduce too frequent new changes. In most European countries, cardiology training is constituted by a period of training in internal medicine (1–2 years) and 3–4 years' training in Cardiology, covering the different invasive and non-invasive fields. The ability to perform diagnostic coronary angiography and right and left cardiac catheterization is still part of the general training for all Cardiologists in most European countries, with a minimum number of procedures often indicated in the curriculum of trainees in general cardiology. This is reflected by the Core Curriculum in Cardiology, recently published by the Education Committee of the European Society of Cardiology [1]. In the Curriculum a minimum of 300 catheterizations as first operator is required. For diagnostic catheterization (right and left, with coronary angiography and left ventriculography) the level required (III) implies that the trainee is able to “independently perform the procedure unaided” at the end of his/her training. Also percutaneous interventions are part of the techniques required, with a lower number (50) and a Level II which indicates “practical experience but not as independent operator”. The Core Curriculum, promoted and implemented by the European Society of Cardiology and recently updated, implicitly recognizes that percutaneous interventions are part of a different Subspecialty training.

To promote the application of the Curriculum and issue the Diploma of European Cardiologist, a certificate not required to practice in individual countries but helpful to move across different European countries, a permanent body joining the expertise provided by the European Society of Cardiology and the authority of the UEMS has been created. This permanent Committee, called European Board of the Specialty in Cardiology, has already endorsed the concept that practice of activities like interventional cardiology, electrophysiol-

ogy and pacing, cardiovascular imaging, require a specific and additional training and has set the general rules regulating its organization, devolving to each individual Working Group or Association the development of the specific educational content of the programs.

The European Curriculum and Syllabus

After several meetings between members of the ESC WG of Interventional Cardiology and the chairmen of the national interventional societies, a Committee was nominated to finalize a Curriculum and Syllabus for interventional cardiology training in Europe. The final document has been published in *EuroIntervention* in 2006 [2]. The intention of the curriculum is to identify an educational process for specialists in interventional cardiology in Europe. The curriculum mandates a two-year program divided into four semesters, with the trainee starting to prepare the patient for the intervention, including diagnostic angiography, and assist the supervisor or another experienced interventionalist performing the angioplasty procedure. It was recommended that the trainee starts working as primary operator for simple angioplasties under close supervision and assists in the most complex angioplasty procedures (bifurcations, thrombus containing lesions, chronic occlusions, diffuse disease, severe calcifications, etc.) till s/he reaches a level of confidence allowing him/her to work as primary and independent operator in both simple and complex coronary interventional procedures. Apprenticeship learning is defined as the mainstay of the training process in interventional cardiology. Candidates are required to be involved in procedure planning, assessment of indications and contraindications, and specific establishment of the individual patient risks based on clinical and angiographic characteristics. The performance of supervised angioplasty procedures is regulated with the goal of a progressive increase of the candidate involvement and direct handling of angioplasties of increasing complexity. A parallel formal learning is also required, ensuring that the candidate achieves sufficient knowledge of all the subjects included in the Syllabus. Trainees are required to attend at least 30 full days (240 hours) in two years of accredited formal sessions locally, nationally or abroad, including attendance of study

days and post graduate courses, national and international courses in Interventional Cardiology, including live courses. Distance learning through journals, textbooks and the Internet is also encouraged and certified. In the Curriculum it is indicated that all trainees must be exposed by the training program to research in interventional cardiology.

It is a formidable challenge to ensure homogeneous high standard training when no central European government can enforce it and in the absence of any legal recognition of this training. The solution proposed by EBSC and approved by the EAPCI and most National Interventional Cardiological Societies and interventional groups is the development of web based platforms dedicated to subspecialty training, with the scientific and educational content determined by EAPCI within a general scheme valid for all the Subspecialties approved by EBSC [3]. The platform is currently under development and will offer to the trainee the possibility to document attendance of accredited formal training courses and to record their catheter lab based procedures [4]. The website will ask for mandatory reports of Directly Observed Procedures, appraisal from the program director, a 360 degrees assessment involving medical colleagues but also nurses, radiographers, technicians and patients. The final judgment should report the trainee's ability to interact with cath lab staff and colleagues, attention to minimize patient risk and attitude to discuss complex procedures with more expert colleagues, ability to make independent appropriate choices and cope with emergency situations. No final summative examination is envisioned at the end of the training, but multiple choice questions (MCQ) are embedded into a first section testing theoretical knowledge and covering all items included in the Syllabus, and a second series of MCQ in present under "Skills", using real or simulated clinical cases to appraise practical experience.

Training centers are asked to fulfill technical and staffing requirements such as having an independent interventional cardiology unit, allowing the trainee to follow the patient from the beginning to the completion of the interventional treatment, having a volume of at least 800 coronary angioplasties per year including acute coronary syndromes and primary angioplasty for acute

myocardial infarction. At least two certified supervisors must be available, with an experience of at least 1,000 coronary interventions and more than five years experience mainly dedicated to interventional cardiology.

These activities have already promoted changes de facto or via a legal governmental approval of the training programs of interventional cardiology in most European countries. A final year of subspecialist training after a common trunk of three years in general cardiology has been adopted in most countries, with an additional year of fellowship encouraged. The emphasis posed by the EAPCI and the National groups of interventional cardiology on education and training [5] has gained the consensus of all the components within cardiology. Trainees enthusiastically subscribe to the dedicated courses organized for fellows, modeled after similar initiatives of the US Society for Cardiac Angiography and Interventions. Europe, the cradle of modern interventional cardiology, is being reinvigorated to ensure this tradition is continued by competent and dedicated physicians, sharing common knowledge, skills and professionalism throughout Europe.

The State of Interventional Cardiology Training in the USA

The development of training and education in interventional cardiology in the United States followed a path similar to that in Europe. Initial training in percutaneous transluminal coronary angioplasty (PTCA) occurred via attendance at a live demonstration course in Zurich given by Dr. Andreas Gruentzig and his colleagues. At that time (late 1970s, very early 1980s), there was only one manufacturer of PTCA equipment in the USA. Initially they would not sell equipment to hospitals unless the operator had a diploma from attendance at a Gruentzig course and the hospital had Institutional Review Board (IRB) approval to perform PTCA. As the procedure gained acceptance and Dr. Gruentzig moved from Zurich to Emory University in Atlanta, Georgia, more “Courses in Angioplasty” began to appear and more companies began selling PTCA equipment. With this, the requirement for IRB approval of the procedure disappeared and certification of an

individual as “PTCA competent” was left to the discretion of individual hospital credentialing committees.

PTCA became accepted very quickly as an appropriate alternative to coronary artery bypass grafting (CABG) for a select number of patients. Add to this the pioneering work of Dr. Geoffrey Hartzler in late 1980 in performing “direct” angioplasty (as he termed it) in acute myocardial infarction, and the impetus to expand the field of angioplasty was very strong indeed. On the job training through attendance at live demonstration courses and preceptorships rapidly expanded the number of physicians performing angioplasty. PTCA procedures were, by necessity, performed only in hospitals which had an open heart surgery program as the requirement for urgent CABG due to coronary dissection or acute closure was not infrequent in this pre-stent, pre-glycoprotein 2b/3a era. Since a large proportion of these hospitals with on-site CABG and PTCA programs were teaching hospitals with training programs in cardiology, exposure to PTCA became a regular part of basic cardiology training. The core training program in cardiology consisted of three years of internal medicine training followed by three years of cardiology training. This three-year cardiology program covered all aspects of non-invasive and invasive cardiology. As a result, new graduates of programs having PTCA on site began to be certified by their program directors as being capable of performing PTCA.

In this early era, there was no nationally specified curriculum of training in interventional cardiology and, as a result, this process was essentially an unstructured apprenticeship. The graduates of these programs were products of a highly varied educational experience, some with excellent cognitive as well as technical exposure and some with limited cognitive and/or technical exposure.

As the field grew and patient and technical complexity increased, programs began to electively add an additional year of training for persons wishing to pursue careers in interventional cardiology. According to survey results, by 1993 approximately half of the then approved cardiology training programs were requiring an additional year of training if graduates wished certification in interventional procedures [6].

This rapid growth led both The Society for Cardiovascular Angiography and Interventions and The American College of Cardiology to discuss in the early 1990s a means to structure and codify the interventional cardiology training process. An added impetus was the concern that patient outcomes might be compromised by low volume operators with limited training, especially if performing in low volume hospitals. This was supported by several publications which showed a clear relationship between lower operator volumes and increased rates of emergency coronary artery bypass surgery in both the pre-stent and stent eras [7,8].

As a result, a group of interventional leaders began conversation with the American Board of Internal Medicine (ABIM), the American Board of Medical Specialties (ABMS), and the Accreditation Council for Graduate Medical Education (ACGME) about creating a new subspecialty of interventional cardiology. It is requisite that all these bodies interact in order to create a new medical specialty, designate an approved training pathway, and offer certification of competence in that specialty.

In order to recognize a new specialty area, the ACGME requires the following criteria be met:

1. The new specialty signifies the differentiation of a new specialty based on major new concepts in medical science.
2. The new specialty is based on substantial advancement in medical science. The necessary training must be sufficiently complex or extended that it is not feasible to include it in established training programs.
3. There will be sufficient interest and resources available to establish the critical mass of quality training programs with long term commitments for successful integrating of the graduates in the health care system nationally.
4. The new discipline is recognized as legitimate and significant by the medical profession in general and the closely related specialties in particular for a consensus of the training required to perform in this new field.
5. That training in the new field is recognized as the single pathway to the competent preparation of a practitioner in this discipline.

Additionally, the ACGME requires that a number of other criteria be fulfilled to warrant a

new training pathway. Detailed information on these requirements is available on the ACGME website. [9] As is evident, the creation of a new accredited subspecialty is a highly structured and codified process requiring much thought, effort, and coordination with other specialty areas. As a result of these extensive discussions, in 1999 the ACGME began reviewing and certifying training programs in interventional cardiology.

In addition to these ACGME training requirements, the ABIM had to find, amongst other things, that the specified body of knowledge is testable and objectively assessable. In 1999, the ABIM created a Certificate of Added Qualification in Interventional Cardiology (now simply called Certification in Interventional Cardiology), and the first examinations were given in the autumn of that year. To be eligible, a candidate had to hold a valid existing board certification in internal medicine and cardiovascular diseases. The candidate then applied through either the practice pathway (no formal interventional fellowship) or the training pathway (with formal interventional fellowship) meeting specified procedural requirements. The practice pathway ended with the 2003 examination. Thereafter, all applicants had to qualify via the training pathway with graduation from an ACGME approved interventional fellowship experience. The reason for this somewhat complex interweaving of eligible training pathways was to allow existing practitioners without formal interventional training to take IC boards until the training pipeline was established.

The IC examination is a timed multiple choice format examination given over two days. At the present, the question content is divided as follows:

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|-------------------------|-----|
| • Case selection | 25% |
| • Procedural techniques | 25% |
| • Imaging | 15% |
| • Pharmacology | 15% |
| • Basic science | 15% |
| • Miscellaneous | 5% |

Detailed information on content is available on the ABIM website [10] At the time of writing, the ABIM is preparing to utilize simulation in upcoming examinations in order to more adequately assess examinees technical skills and intra-procedure decision making.

Training and education are living processes undergoing constant evolution. In 2004 the ACGME promulgated new educational guidelines for all graduate medical education programs in the US and specified that all training had to comply with the six core competencies which are part of the Outcomes Project. These are:

- Medical Knowledge (MK)
- Patient Care (PC)
- Practice Based Learning and Improvement (PBLI)
- Systems Based Practice (SBP)
- Professionalism (P)
- Interpersonal and Communication Skills (ICS)

Details regarding these, procedural exposure, conferencing, research, and other ACGME requirements are available at their website [11].

As a result of these highly structured and codified requirements, training and credentialing in the US has achieved a high standard of excellence. The requirement of a structured didactic curriculum along with case conferences, basic science, conferences, morbidity and mortality conferences, and a required research project assure each trainee of a comprehensive and intensive training experience. The trainee is accepted in the program for one purpose only—to educate him/her. The notion of an unstructured apprenticeship built around clinical service to the mentor is no longer acceptable.

The next challenge to be faced is how to accommodate training for non-coronary interventions and structural heart disease within the existing framework. Note that according to the existing training documents, current IC training is specifically focused on coronary intervention. Adding this to the existing IC curriculum would require additional conversations with the ACGME, ABIM, and ABMS as they would have to agree to this plan according to the criteria enumerated above. Regardless of the outcome of these discussions, some form of formal, structured education beyond coronary intervention seems both likely and necessary.

In summary, the process of training and credentialing in interventional cardiology in the United States has evolved into a highly structured and codified process. Such training was initially obtained in the context of the basic three-year curriculum in cardiology and then developed into an

additional year of training at many institutions but without clearly outlined expectations of didactic or clinical content. These unstructured apprenticeships then evolved into the current system of ACGME approved training in interventional cardiology beginning in 1999. In the same year, the ABIM began administering written examinations in interventional cardiology to provide “board certification” in the sub-sub-specialty. Until 2003 one could take these examinations via the practice pathway which required no formal training in IC but substantial experience. Thereafter, only graduates of ACGME approved IC programs were eligible for these examinations which provide a 10-year time-limited certification. At the end of that time, the applicant must re-take the examinations to maintain certification. As the field of IC continues to evolve, it seems highly likely that the current guidelines will be modified to include specified training in non-coronary interventions and/or structural heart disease with curricula and certifying examinations to match.

Conclusion

Interventional cardiovascular practice remains a dynamic, evolving and demanding subspecialty of cardiology which requires significant personal commitment to training and significant system resources to provide properly structured training. The evolution of similar systems in Europe suggests that this formalized process is superior to unstructured apprenticeships/fellowships and there may come a day when a truly international program of training and certification may be available.

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