Point of view

A brief history of coronary interventional cardiology

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Introduction

The history of interventional cardiology is an exciting journey characterized by intuition, genius and chance. In 1958 Mason Sones was about to perform aortography of a young patient when, during the injection of contrast medium, the tip of the catheter slipped into the proximal tract of the right coronary artery and about 50 ml were introduced into the coronary tree of the patient. Oscilloscopy indicated a prolonged period of asystolia, resolved by the bouts of cough of the still conscious patient. Sones was quite relieved, since he had feared ventricular fibrillation, but during the following days he started to think that the casual, yet potentially fatal, episode might open the way to the experimentation of a new invasive diagnostic technique. In 1959 Sones performed the first selective coronary angiography[1,2].

Remote history

As a matter of fact, cardiac catheterization had been experimented in the horse by Hales in 1711, more than two centuries before Sones's experience. During the 19th century interventions inside the thorax of human beings were considered as nearly always lethal, and so not ethically feasible. In spite of the important scientific achievements of the '800, such as the discovery of X-rays in 1895 and their immediate application in medicine, which were fundamental for the future development of interventional cardiology[3], it was only in the third decade of the 20th century that Forssman (1929) conducted his right-heart self-catheterization under fluoroscopic control. During the '40s Richards and Cournard completed the disclosure of the right heart; in 1941 they were able to measure, for the first time, hemodynamic parameters during the catheterization of the right sections. Cope, Ross and Zimmerman disclosed the left heart during the following decade, and in 1956 Forssman, Cournard and Richards were awarded the Noble Prize for their studies on the heart[4]. During the '50s and the '60s Sones worked hard to improve the technical characteristics of his (cath) laboratory and to increase the safety and efficacy for the patients, collaborating with a number of specialists[5]. In 1953 Seldinger perfected his vascular percutaneous approach, a technique destined to have a major impact on invasive interventions on the heart[1].

As far back as 50 years ago the progress achieved in this field already appeared to be the result of the collaboration of physicians, engineers (who elaborated a fluoroscopic image intensifier useful for the catheterization laboratory) and other professionals (Sones collaborated with Eastman Kodak to improve the characteristics of the film used for angiographic purposes)[2].

The development of percutaneous techniques on peripheral arteries also demonstrates the strict relationship between scientific method, clinical intuition, and the casualness of an accidental observation. While performing a routine peripheral angiography, Charles Dotter unintentionally introduced a guide and a catheter through a stenosis in the iliac artery, thus achieving the recanalization of the vessel (1963). In 1964, after a series of preliminary studies on ca-

davers, Dotter performed the first mechanical dilation of a peripheral artery in a living person, and in 1967 Judkins elaborated his femoral approach for coronary angiography[6]. Dotter's studies and Gianturco's research performed later, were aimed at the development of new balloon catheters, and represented the basis for the revolutionary experience of Andreas Roland Gruentzig, the first physician to dilate a coronary artery in a living human[7].

Recent history

Dotter's accidental catheter recanalization of a peripheral artery ushered in the era of intervention, crowned by Gruentzig's balloon angioplasty in 1977. This achievement appears to be the result of a long process. For many years Gruentzig had been trying to solve the problem of uncontrolled dilations of the latex balloons available until then, but it was only in 1974 that he was able to prepare the first balloon catheter made of polyvinylchloride, an instrument with which, from 1974 to 1977, he was able to perform many dilations of the stenoses of peripheral arteries[4]. During the same period he practiced on an animal model (dog) to increase his experience with the dilation of coronary arteries using his miniaturized instruments, and published his famous 1976 poster presented at the Annual Scientific Meeting of the American Heart Association in *Circulation*[8]. However, the international scientific community was not yet prepared for his revolutionary technique, and the paper prompted widespread skepticism among physicians. Only Gruentzig's great determination led him to his achievements.

On September 14th, 1977, the coronary angiography performed by Gruentzig in a 38-year-old male patient revealed a high-grade stenosis of the proximal left anterior descending coronary artery just proximal to the first large diagonal branch. Two days later, the first coronary angioplasty procedure was performed without complications; in 2000, 23 years later, the same patient underwent a new control coronary angiography[9]. Unfortunately, Gruentzig could not follow the destiny of his first human patient, since he died in an airplane crash in 1985. This premature death prevented Gruentzig from seeing the beginning of the comparison trial he had insisted should be conducted (angioplasty versus coronary artery bypass surgery – EAST trial) in order to rigorously test the efficacy and safety of the new therapeutic technique[10,11].

The first stents were implanted in subjects with ischemic heart disease in 1986, even though they had previously been used in a number of medical and surgical disciplines. The first use of the word "stent" to indicate a device useful in reshaping an anatomical structure was in 1916, in the field of odontology. The word derives from the name of an English dentist, Charles Stent, who in 1856 invented a dental impression compound known as "Stent's material"[12].

In the '80s, the indications for stent placement basically consisted of the treatment of acute vessel closure during angioplasty and the management of restenosis after an initially successful angioplasty. The high rate of complications did not discourage the cardiologist investigators who, in 1991, initiated randomized trials to compare stenting and balloon angioplasty in selected patients with discrete lesions in native coronary arteries. In 1994, through the introduction of ticlopidine in addition to aspirin after stent implantation and of a modified deployment technique to allow optimal stent expansion, a new era of stenting began[13].

Evolution of techniques and materials and recent developments

In 1974 Gruentzig modified Dotter's multiple catheter system and developed a double lumen balloon pre-formed catheter. This catheter allowed for a more limited arterial puncture and for the use of circumferential (rather than axial, as in the Dotter's) pressure. However, in 1977 the equipment used to perform angioplasty was still quite rudimentary: guide catheters had a 9-10F diameter, were made of solid Teflon and had scarce torque control. Only in 1980 were new guide catheters, composed of three strata, introduced. At the same time introducers for angioplasty were implemented, to facilitate the insertion of guide catheters. The evolution of dilator catheters and of coronary guides has been even more impressive during the '80s when the guides were particularly improved in terms of flexibility and orientation[1].

During the '90s, in an era of evidence-based medicine, the progress of interventional cardiology has been rapid and successful, and at present percutaneous coronary interventions are considered the gold standard for the treatment of acute myocardial infarction, provided that the procedure is performed by experienced and skilled operators and that patients have rapid access to a dedicated catheterization laboratory. Primary percutaneous transluminal coronary angioplasty for acute myocardial infarction also includes critical organizational and professional features, such as quick transportation and the appropriate training of the entire sanitary staff involved, in a national health context still characterized by the limited availability of dedicated cath laboratories.

At present, a variety of new technologies for percutaneous coronary revascularization, including drug-eluting stents, intracoronary radiation therapy, and glycoprotein IIb/IIIa inhibitors is available for the optimal treatment of patients with cardiac ischemia. This renders the treatment of patients with acute myocardial infarction more complex and integrated and improves the outcome of subjects undergoing percutaneous interventions[14]. As a matter of fact, the rate of restenosis may be reduced by current advanced medical therapy. The

progress of pharmacological therapy has historically paralleled the development of interventional cardiology; even more, medical therapy has in many cases been specifically designed to support interventional cardiology, as in the case of drug-eluting stents.

With specific regard to stents, the Palmaz-Schatz stent was one of the first available devices; the frequent observation that a common site for in-stent restenosis was located at the articulation led to the modification of the design of this kind of stent to a spiral. Unfortunately, the new design increased the rigidity of the device and made it more difficult to track through the tortuous segments of the artery. Successive developments have improved both the early and late outcomes following percutaneous coronary interventions, and the stent characteristics, including design, stent strut thickness, and stent metal alloy, are associated with different rates of restenosis. Even though different issues still have to be solved, among them the use of brachytherapy, recent improvements in stent design and the presence of new drug-eluting stents promise further developments in the field of interventional cardiology all over the world, including Italy.

Interventional cardiology in Italy

Thirty years ago, in 1973, a group of Italian hemodynamists met in order to standardize techniques and responses to this new branch of cardiology. The meeting was important even in the perspective of creating a useful network for the exchange of experiences and the collection of statistical and epidemiological data. In 1975, the group took the name of the Italian Group of Hemodynamic Studies (Gruppo Italiano di Studi Emodinamici - GISE). Since its establishment 48 Italian cath laboratories have been involved, and in 1998 the current charter was approved and the association took the name of the Italian Society of Invasive Cardiology (www.gise.it).

In Italy too, as in the rest of the world, the development of interventional cardiology has followed precise steps. After the introduction and the initial application of angioplasty procedures in the ’60s and in the ’70s, techniques and supporting technology improved notably during the ’70s and the ’80s, with a rapid expansion of clinical indications in the second half of the ’80s. In the early ’90s new technologies were introduced and in the second half of the ’90s many Italian researchers became involved in the amazing challenge of the treatment of restenosis, leading our country to play an outstanding international role in the scenario of interventional cardiology.

In Italy many top-grade centers are today available for the interventional treatment of cardiovascular diseases, among them Milan, Naples and Pisa. With special reference to percutaneous coronary interventions, realities such as that in Florence represent a reference for foreign experiences as well, since the availability of interventional cardiology is round the clock 7 days a week every day of the year, with an enormous volume of procedures resulting in a remarkable improvement in the prognosis of patients with acute myocardial infarction. The strong integration of the roles of a whole work team is crucial in modern medicine, and particularly in interventional cardiology, so as to achieve and consolidate clinical results that will have a large social impact on the general population. To reach such an objective, a carefully coordinated and well integrated organization of the territorial health care system is also mandatory.

Conclusions

Many authors acknowledge that in the last 50 years at least three major revolutions have transformed cardiology, and perhaps the whole of medicine.

The introduction and diffusion of interventional cardiology is considered one of them. Together with the social revolution (the plummeting esteem for the medical profession, reflecting disenchantment, coupled with the rapid emergence of the recognition that health care is both a right, rather than a privilege, and a social and ethical duty) and the most recent revolution in molecular and cellular biology, the introduction and diffusion of interventional cardiology is the third revolution and has provided powerful therapeutic tools demanding technical as well as cognitive expertise[15]. So as to overcome still existing medical (e.g. restenosis) problems, these tools need to be further refined in the near future. At the same time, the development of professional and management expertise is necessary to overcome the organizational obstacles that today still limit the widespread diffusion of evidence-based effective treatments, such as interventional cardiology procedures.

A glance at the past allows us to see that the development of major transitions, such as that which interventional cardiology has proved to be, needs (as stressed) the full integration of different skills and abilities. A glance at the future permits us to hypothesize that new approaches are needed for the optimal training of clinicians with various areas of interest, for investigators in basic and clinical research, and, last but not least, for an optimal responsiveness to the needs of patients. These approaches, as even a brief history of interventional cardiology indicates, will have to be developed whilst remaining faithful to our clinical and scientific heritage, the awareness of which constitutes a fundamental basis for the comprehension of the present as well as of the future.

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