Presidential address

The adventure of cardiac surgery

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1. Introduction

It has been a great pleasure to serve the Association during this year as your President, and an honour and privilege to continue the work done during the last 15 years by so many people. It is impossible to mention every one, but let me thank some, for their dedication and exceptional efforts: the founder of our Association and first President Francis Fontan, our former two editors, Hans Borst and Marko Turina, and our Secretary General Torkel Aberg. Besides them, let me especially thank my wife, for her continuous support and help, without which, I would not be on this podium today.

It is a great satisfaction to address you on this occasion, the first joint meeting with the ESTS. I am sure this represents a belief that joint efforts can produce much to both Societies. I am sure this is going to be, so far, the most important thoracic meeting and hope that it will be a great success and an experience to repeat in the future.

Today, here in Lisbon, let us remember the great adventure started by Portugal and Spain, exploring the frontiers of Europe towards unknown lands. The Portuguese designed the first boats for oceanic navigation and started to explore the coasts of Africa, down and around Cape Hope towards Asia. Spain took the challenge to explore the West, trying to arrive to India and discovered a New World. That was the beginning of the expansion and influence of Europe on the rest of the world. Five hundred years later (1492–1992) we are enjoying a world without walls or barriers for communication. We are already in the third millennium, with renewed votes, hopes and expectations for the future. So it is natural to open your imagination to applications of new technologies and make predictions about any field of knowledge. But at the same time, it is very easy to forget about the past and how we arrived where we are today.

I would like to review the most important achievements in cardiac surgery, especially some of the contributions from Europe, without ignoring so many others mainly from North America. There are more than 100 years of cardiac surgical history, with two different periods, each one of 50 years more or less: the before and the after of open heart surgery.

2. Extracardiac and closed cardiac surgery

The history started in Europe, in 1896 (September 9th), when Ludwig Rhen, in Frankfurt, sutured a stab wound in the right ventricle of a young gardener [1–2]. From then on, the myth and respect of the heart was broken, and the sacred seat of the soul was open to surgery. It is well known, the quotation attributed to the famous Viennese surgeon Theodor Billroth: “Whoever attempts to operate upon the heart, will fail. He will lose the respect of his Colleagues”. It obviously reflected the general belief that the heart was the seat of the soul, therefore should not be handled. Not without reason, we must remember that for the ancient Egyptians, everything came from the heart: the thoughts, the actions, the tears and even the sperm. This is why the heart was always put back inside the mummified body.

Cardiovascular surgery would never have developed without the incredible work of Alexis Carrel, who, at the beginning of the last century, started vascular anastomosis in Lyon, by devising fine needles and sutures. Later, in 1904, he continued his experimental work in Montreal, Chicago and New York. He developed the techniques for suturing arteries, performed vessel transplants and used artificial glass tubes to replace arteries. Without any hesitation, we can be certain that he was the real father of vascular surgery. In 1912, he was the first person in America to be awarded the Nobel Prize for Physiology and Medicine, inspite of being French. He was also ahead of his time when he evolved methods for heart valve surgery, resections...
of aortic and ventricular aneurysms and coronary artery bypass, and he even predicted the possibilities of organ transplantation, as well as the application of the experimental caval occlusion technique for open heart surgery [3,4].

In 1920, back in Europe, Rhen, and simultaneously Sauerbruch, were the first to perform a pericardectomy [5–8]. In 1923, Elliot Cutler in Boston attempted the first mitral valvulotomy in a 12-year-old girl, introducing a valvulotome through the apex of the left ventricle [9]. But it was in England, in 1925, that Henry Souttar performed the first mitral valvulotomy introducing his finger through the atrial appendage and splitting the fused commissures [10]. But these early operations for mitral stenosis were interrupted soon afterwards, for almost a quarter of a century.

Some years later in 1938, Robert E. Gross, in Boston, successfully closed a patient ductus arteriousus [11]. Not far from what is considered the beginning of modern heart surgery in 1944, Alfred Blalock with the support of Helen Taussig, the founder of paediatric cardiology, at Johns Hopkins Hospital, performed the first subclavian to pulmonary artery anastomosis for tetralogy of Fallot [12]. In 1945, in July and October, Gross in America and Clarence Crafoord in Europe, independently carried out the first two successful resections of a coarctation of the aorta, with end to end anastomosis repair [13,14].

The transition from surgery of the major vessel towards closed cardiac surgery began in 1947, when Thomas Holmes-Sellors, in London, performed the first pulmonic valvulotomy [15,16]. Russell Brock in 1948, combined it with a pulmonary infundibular resection, known as the Brock procedure [17–20]. In the same year on the 10th and 16th of June, Charles P. Bailey from Philadelphia and Dwight E. Harken from Boston, each performed a successful mitral commissurotomy [16,17,21–23] and in September, Brock did his first mitral valvulotomy in England [16]. Different technical modifications were used, but Charles Dubost in Paris, in 1953, was the first to introduce an expandable dilator inserted through the left atrial appendage. Later in 1954, Oswald Tubbs in England used an adjustable transventricular mitral dilator, introduced through the apex of the left ventricle. Dilators were very helpful in splitting the commissures. In 1952, Bailey and Brock performed successful aortic valvotomies [16].

3. Open heart surgery

The second part of the 20th century represents the beginning of a completely new era for cardiac surgery; Wilfred G. Bigelow from Toronto, after many years of experimental research, discovered that under certain controlled conditions, hypothermia reduced the body oxygen requirements [24,26]. We ought to remember that before 1946, medical scientists believed that any lowering of the body temperature increased the oxygen requirements, and was considered dangerous and a cause of shock [26]. In 1950 he reported, at the American Surgical Association, the potential use of hypothermia with venous inflow occlusion, to access, explore and correct internal cardiac lesions under direct vision [25,26].

Two years later, 2nd September 1952, John Lewis from The University of Minnesota, carried out the first successful open heart operation in history using hypothermia. He closed an atrial septal defect in a 6-year-old child [27]. The main limitation of this method was time, not being able to correct lesions that would take more than 8–10 min.

The most important achievement was the first successful operation with total cardiopulmonary support using a pump screen oxygenator, by John H. Gibbon. He closed an atrial septal defect in an 18-year-old girl, on 6th May 1953 [28]. Gibbon lost the following four patients, which made him abandon his endeavour, after more than 20 years of investigation.

The lack of initial success with the screen pump oxygenator, encouraged Walton Lillehei to investigate and use the cross-circulation technique, using a ‘donor’ as an oxygenator, being one of the most imaginative and daring procedures. In 1954 (March 26th) at the University of Minnesota, he performed his first ‘controlled cross-circulation’ procedure, closing a ventricular septal defect in a boy, with the father as donor. Lillehei used cross-circulation in 45 operations, being the first one to correct a ventricular septal defect, an atrio-ventricular defect and a tetralogy of Fallot [29–32]. The cross-circulation technique had many limitations, because it was only suitable for children with a parent with a compatible blood group and had the ethical dilemma and concern about safety of the parent. Nevertheless, it greatly contributed to the understanding and development of open heart surgery at the time.

In 1955, John Kirklin at the Mayo Clinic, started to use the modified Gibbon screen pump oxygenator (Mayo–Gibbon–IBM prototype) with promising results that helped to establish the use of cardiopulmonary bypass [33]. In 1955 and 1956, open heart surgery was restricted to the University of Minnesota Medical Centre and the Mayo Clinic. But fortunately, soon afterwards, some other places had such facilities. Viking Björk with Craford, from Sweden, developed a stainless steel rotating disc oxygenator, called the Bjork-Aga oxygenator. It was adapted by Earle Kay from Cleveland and Fredrik Cross from Minnesota, creating the Kay–Cross disc oxygenator mode. Denis Melrose in London, Frank Gerbode in San Francisco and Donald Effler in Cleveland also used and further improved the disc oxygenator [34,35]. Melrose’s contribution and influence were very important in the development of cardiac surgery in Europe. We had the privilege of having him and Hugh Bentall to help us at the beginning of our open heart programme in Barcelona. But Melrose will always be remembered as the first to describe elective cardiac arrest to improve conditions during open heart surgery.

In 1955, DeWall and Lillehei, developed the bubble oxygenator and the clinical use of plastic disposable bag
oxygenators [36]. Lillehei also introduced haemodilution in open heart surgery, but it was Cooley who popularized haemodilution as well as the use of disposable oxygenators [37].

In 1956, William Sealy of Duke University in North Carolina, was the first to combine moderate hypothermia (29–31°C) with extracorporeal circulation [38]. Charles Drew in London, in 1959 used the lungs of the patient as an oxygenator, with two separate extracorporeal circuits of the heart, and a heat exchanger system in the left heart side circuit to achieve profound hypothermia (15°C). Then, with a controlled period of total circulatory arrest, he was able to work inside the heart [39]. Later on, profound hypothermic circulatory arrest became the technique of choice to correct aortic aneurysms and some complex congenital heart anomalies.

Cardiopulmonary bypass provided the basis for treating any cardiac lesion and opened a bright future for development. In the following decade, as cardiopulmonary bypass became more reliable and simple, it favoured the treatment of all kinds of congenital and acquired cardiac lesions, being one of the most creative and expanding times in cardiac surgery. There is no doubt as to why, Kirklin, in his EACTS Honoured Guest Lecture, in Munich in 1991, named this time as the ‘innovation’ era in cardiac surgery.

I was fortunate enough to have been in medical school at the beginning of open heart surgery, and have had the privilege to start training in Cardiovascular Surgery in the early 1960s, when almost everything started to develop in Europe and particularly in Spain. I was also very lucky thereafter, to be accepted to work with Donald Ross, Keith Ross and Magdi Yacoub at the National Heart Hospital in London, at the time when so many innovations were being made. I recall it all as a very challenging and a most rewarding adventure.

4. Valve surgery

4.1. Valve repair procedures

Lillehei in 1956 was the first to perform an open mitral commisurotomy and a mitral annuloplasty [40]. Closed valve surgery soon gave way to the more precise methods with direct vision of the valves. Credit must be given to Geoffrey Wooler from Leeds, who in 1957 started to repair mitral incompetence, reducing the length of the dilated posterior valve ring, with the use of asymmetrical mattress sutures through the annulus [41]. Kay and Reed further developed annuloplasty techniques, and McGoon the method for correction of ruptured chordae [42–46].

Alan Carpenter in 1971 introduced the rigid valve ring to maintain segmental plication of the posterior leaflet, as well as many other innovative and advanced techniques in valve reconstruction [47–49]. Carlos Duran subsequently proposed the use of a flexible sewing ring to be able to maintain annular motion during contraction [50–53]. Another annuloplasty ring worth mentioning was the adjustable ring introduced by Miguel Puig-Massana [54–56]. It has been shown that the repair in rheumatic valve disease is more difficult and less stable in comparison with degenerative valve lesions [49,53,57,58]. Recently in 1995, Ottavio Alfieri devised an original and simple technique to correct mitral incompetence, creating a double-mitral orifice (the double-orifice technique), with very good and reliable results [59–62].

Benefits of repairing rather than replacing the mitral and tricuspid valves are unquestionable, with more favourable early and long-term survival results [49,52,55–58]. It has also become evident that preservation of mitral subvalvular chordal apparatus during valve replacement is essential to maintain ventricular function [63–65].

Tricuspid valve was also favoured by similar repair techniques. Norberto G. DeVega, described the semi-circular annuloplasty technique, a successful method to correct tricuspid insufficiency reducing the tricuspid annulus with a double continuous purse string suture [66,67].

Different aortic valve repair techniques have been used in the past, but they have not been so reliable and permanent as conservative operations of the atrio-ventricular valves. Recently, Carlos Duran and other groups, have reintroduced and expanded such techniques, particularly with indications to young patients [68–70].

4.2. Mechanical valves

Charles Hufnagel in 1952 (September 11th) was the first to implant a prosthetic valve into the descending aorta of a human being [71,72]. His pioneering work and efforts clearly opened the future for cardiac valve prostheses. In fact, his original caged ball valve was the model for the first successfully implanted mitral and aortic prosthetic heart valves by Dwight Harken and Albert Starr, in May and August 1960, respectively [73,74].

New ingenious mechanical heart valves made of different materials were designed and clinically tested. Many well-known cardiac surgeons involved themselves in collaboration with the industry to produce different prostheses, trying to improve haemodynamic characteristics and durability and to avoid the emerging valve related complications. The caged ball valves were followed by low profile valves with central disc conical occluders or with tilting discs. In Europe, Viking Björk popularized the tilting disc valves. Different models of Björk–Shiley valves with flat, conical, spherical and convexo-concave discs were produced, improving thromboembolic complications [75,76]. Nevertheless, multiple reports of strut fractures in large size 70° opening angle valves, stopped production of this valve [77,78]. A new monostrut valve was produced with very good results [79–80], but the high incidence of mechanical failures of the old model and secondary serious legal problems lead to the end of the Shiley Company.
The most important issue in the valve industry was the introduction of pyrolytic carbon by Jack Bokros of General Atomic Inc. (later CaboMedics Inc.). The incorporation of pyrolytic carbon as a thromboresistant surface and highly durable material, changed and solved many of the problems of the prosthetic valves and opened the possibility to develop and design the modern bileaflet valves based on the old concept of the butterfly valve of Vincent Gott and William Daggett in 1963 [75].

There were many different types and models of mechanical valves, but for simplicity they can be classified into four groups:


Most of the prosthetic valves produced in those days [75,76,81] are now not in use (*). Present results of modern mechanical valves are very good and reliable.

4.3. Tissue valves

Many surgeons have had serious doubts and all kinds of reservations about implanting prosthetic heart valves. Others, especially in Europe, could simply not obtain them. In 1956, Gordon Murray in Toronto successfully implanted an aortic homograft in the descending thoracic aorta and gave the possibility to use homograft valves for valve replacement [82]. Carlos G. Duran and Alfred Gunning developed in Oxford, the method to harvest, prepare and implant aortic valve homografts [83]. This previous work helped Donald N. Ross to perform in London, on 24th June 1962, the first successful implantation of an aortic homograft in the subcoronary position [84]. Two months later, Brian G. Barrat-Boyes in Auckland, New Zealand, also implanted an aortic homograft [85]. Other surgeons such as Kirklin, Angell and Shumway in America, and O’Brien in Australia used them, but it was in Europe where Ross and Yacoub persisted worked with homografts [86–93].

In 1966, Ross used aortic homografts for the correction of pulmonary atresia [94]. The following year, Dwight McGoon used a homograft for the correction of truncus arteriosus [95]. This started the use of homografts for the correction of many complex congenital heart diseases [96].

The wide experience of Ross in the use of aortic homograft valves and his continuous search for preserving viability of valves, allowed him to perform the first pulmonary autograft valve operation for aortic valve replacement in 1967 [97]. He had the conviction that the autograft valve would remain viable and could also have the potential for growth in children [98,99]. The outflow tract of the right ventricle and pulmonary valve were reconstructed with an aortic homograft. Originally, the pulmonary autograft valve was placed in the subcoronary position, but later it was used for complete aortic root replacement with reimplantation of the coronaries, known now, as the ‘Ross operation’ [99–101].

Past attempts of mitral valve replacement with mitral homografts led to results with early failures [102]. Christian Acar revitalized interest using cryopreserved mitral valves, with new techniques for fixation of the papillary muscles and annuloplasty rings [103–105]. Nevertheless, results are difficult to judge because of few numbers and short-term results. Tricuspid valve replacement by a mitral homograft has been used by José L. Pomar and Carlos Mestres in Barcelona, in patients with infective endocarditis, with good results [106–108].

The lack of sufficient homograft valves brought about the search to preserve heterograft valves and find other tissue substitutes. Duran and Gunning had continued their experimental work in Oxford, and had started to preserve and implant porcine aortic valves. Based again on their research, Jean Paul Binet in Paris together with Duran and Carpentier implanted, in 1965, the first porcine aortic valves, preserved initially in mercurochrome and later in formalin [109]. In 1967, Mark O’Brien in Melbourne also reported the implantation of aortic xenografts preserved in formalin [110]. The same year Marion Ionescu, used a rigid titanium support for mounting porcine valves and later fascia lata and heterologous pericardium valves [110–113]. Alain Carpentier at the same time, implanted porcine xenografts mounted in more flexible stents. William Angell and Norman Shumway designed similar frames for mounting fresh aortic homografts.

Ake Senning in Zurich, was the first to use autologous fascia lata to repair and replace aortic valves [114]. Euriclides D. Zerbini in Sao Paulo used dura mater preserved in glycerol [115].

Initial clinical results with stent mounted aortic homografts, porcine valves and other tissues were poor because of inadequate methods of preservation combined with excessive stress forces on the tissues, which lead to premature tissue failures. Free hand sewn homografts showed better results than stent mounted ones [89].

Alan Carpentier in 1968 employed glutaraldehyde, which was used for tanning leather and enhanced formation of collagen covalent cross-linkage bonds, increasing tissue strength and preventing the denaturation of collagen. The tissues were then non-viable, and their antigenicity was markedly reduced [116]. Soon afterwards, glutaraldehyde
was used to fix porcine and pericardium valves by Hancock, Angell and Ionesco. The use of the term ‘bioprostheses’ was established for xenograft valves mounted in a stent, at the Bioprosthetic Cardiac Valves Symposium, in Munich in 1979 [117].

Carpentier’s efforts and research in the field of xenografts has led to continuous improvement in results. New porcine and pericardial bioprosthesis valves with improved stents, low pressure fixed methods and anticalcification treatment show less structural deteriorations than the first generation stented valves, in mitral or aortic position [118–125]. Pelle-tier and Jamieson have shown that bioprostheses structural deterioration is influenced by the age of the patient at the time of implant, so children and young adults are more prone to present early degenerative changes than older patients. When patients are around 65–70 years old, bioprostheses have shown to be remarkably durable.

The next step in the development of xenografts was the introduction of stentless aortic valves, with the possibility of better durability because of the lack of stent stress forces on the tissues, as well as theoretically better haemodynamic performance because of more favourable effective orifice area at rest and during exercise. Tirone David, Mark O’Brien, Hans Huysmans and Stephen Westaby have been some of the pioneers in this field [126–132]. The real benefits of stentless bioprostheses are still controversial.

4.4. Less invasive procedures

During the past decade less invasive surgical approaches for aortic and mitral valve operations have evolved by modifying previous incisions. Mini-sternal or para-sternal incisions have shown encouraging results, with low mortality and satisfactory postoperative pain control [133].

In 1996, the Stanford group performed the first minimally invasive mitral valve replacements using Port-access™ techniques with intra-aortic balloon occlusion and cardioplegia [134]. The University of Leipzig was the first group in Europe to use similar techniques [135]. In February 1996, Carpentier performed the first video-assisted mitral valve repair through a mini-thoracotomy [136]. Friedrich Mohr performed the largest series of three-dimension video-assisted mitral valve operations [137].

Robotic surgery has been recently applied in mitral valve surgery combined with the Port-access™ techniques. Carpentier and Mohr, in May 1988, were the first to do robotic mitral operations using the da Vinci™ Intuitive Surgical Robotic system, followed by the Munich group [138], and by Randolph Chitwood in North America [139,140]. Different series have shown now that minimally invasive mitral surgery is safe and effective.

5. Congenital heart surgery

Lillehei was the first to correct a ventricular septal defect, an atrio-ventricular defect and a tetralogy of Fallot [30]. As early as 1957 Åke Senning first performed the intracardiac baffle repair for transposition of the great arteries, redirecting both caval venous returns to the pulmonary artery and the pulmonary venous drainage to the aorta [141]. The so-called Senning repair was a physiological correction at the venous return level of the heart [142,143]. In 1963, William T. Mustard in Toronto, used autologous pericardium for the atrial venous correction in transpositions [144]. Both were the standard procedures for many years until the anatomical correction at the arterial level was first performed by Adib D. Jatene in 1975 [145,146]. Magdi Yacoub was the first to correct transposition previously preparing the left ventricle [147,148]. Lecompte introduced the manoeuvre of placing the aorta behind the pulmonary artery, thus reducing tension and eliminating the need for prosthetic graft [149].

Another achievement in the treatment of complex congenital heart disease was accomplished, also in Europe in 1968, by Francis Fontan. He performed the first total cavo-pulmonary connection between the right atrial appendage and the main pulmonary artery, to correct tricuspid atresia [150]. There have been many modifications to his original procedure, all aimed at improving results. Fontan’s operation opened many doors to correct complex congenital heart disease when a double ventricular repair was not possible [151].

It was in the beginning of the 1970s that total correction of congenital heart diseases started being performed, often during the first year of life. Hypothermia and circulatory arrest were used for correction in infants, following the techniques of Kyoto University, which were made popular by Barrat-Boyes [152]. Since then the advantages of primary correction in infancy of many types of complex congenital heart diseases have been proved.

The next step was neonatal open heart surgery, pioneered by Aldo Castaneda in Boston, favoured by the need to perform arterial switch operation during the first weeks of life [153]. The main objective was the early repair of any kind of congenital heart defects which included, besides transposition of the great arteries, truncus arteriosus, total anomalous pulmonary venous drainage, hypoplastic left heart syndrome and any other congenital lesion requiring correction at the neonatal period [153–160]. Other groups in Europe, such as Yacoub, Stark and deLeval in London, Quaegebeur in Leiden, Sibening in Munich, Planche and Vouhé in Paris and many others started, very soon afterwards, to perform neonatal correction.

6. Myocardial protection

Melrose, in 1955, in London, was the first to propose elective cardiac arrest to improve conditions during heart surgery [160]. Cardioplegia was induced by injecting blood with cold hypertonic potassium citrate into the aortic root, with the aorta cross-clamped, in patients on cardiopulmon-
ary bypass. The method was abandoned because inappropriate concentrations of the solution led to ventricular damage and failure.

Shumway introduced the use of local hypothermia for myocardial protection [161]. In Germany, Kirsh and Bretschneider continued inducing cardioplegia and studying myocardial resistance and tolerance to ischemia [162–164]. Their studies, together with the work of David Hearse, in London, and the collaboration of Mark Baimbridge, renewed the interest, worldwide, in cardioplegia [165–167].

Phillipe Menasché in Europe, introduced retrograde sinus cardioplegia delivery in aortic valve operations [168]. Gerald Buckberg in America, developed the oxygenated blood cardioplegia with new concepts and methods to completely avoid myocardium damage [169–171]. Doubtless, the new techniques for myocardial protection and controlled reperfusion have been one of the most important achievements, reducing morbidity and mortality and substantially improving early and late results in cardiac surgery.

7. Aortic surgery

Charles Dubost in 1952, in Paris, was the first to replace an abdominal aortic aneurysm using a homograft [172]. Michael DeBakey and Denton Cooley, in 1956 and 1957, respectively, in Houston, replaced also with homografts the ascending aorta and the aortic arch, using cardiopulmonary bypass [173,174]. In 1958, they introduced the use of synthetic flexible knitted Dacron vascular grafts [175]. In 1965, Stanley Crawford described the inclusion technique to repair thoracoabdominal aneurysms [176].

Hugh Bentall in 1967, in London, reported on the first complete replacement of the aortic root and ascending aorta, using a composite valve graft and reattaching the coronary arteries to the conduit [177]. Cristian Cabrol, in Paris, modified the technique, reattaching the coronary arteries with a vascular graft [178,179]. Replacement of aortic arch aneurysm with the use of deep hypothermia and circulatory arrest was reported first by Barnard in 1963 [180], but it was Randall Griepp, in 1969, who popularized the routine use of deep hypothermic circulatory arrest for aortic arch repairs [181]. Nicholas Kouchoukos, used a similar technique for spinal cord protection, for correction of thoracic and thoracoabdominal aneurysms [182]. Joseph Coselli has vast experience in the correction of thoracoabdominal aortic aneurysm, with very good results [183].

John Bachet, in Paris, introduced ‘cerebroplegia’, with selective antegrade cerebral perfusion with cold blood, which became one of the most effective and reliable methods for cerebral protection [184]. He also popularized the use of gelatine formol biological glue in acute dissections [185]. Hans Borst in Hannover described the ‘elephant trunk technique’ to correct aortic arch and thoracic aneurysms, facilitating the second stage correction of thoracic aneurysm [186–188]. Magdi Yacoub, followed by Tirone David, have been the pioneers in repairing aortic root aneurysms, preserving native aortic valves [189–192]. Marko Turina in Zurich, has successfully used cryopreserved arterial homografts for the treatment of prosthetic vascular infections [193].

One of the most important challenges in cardiovascular surgery has always been and still is the treatment of aortic dissections. Stanford University has been a very active surgical group working in this subject [194]. In the past decade, they have introduced endovascular therapies for acute and chronic aortic diseases [195–198]. I have had the privilege this year to invite Craig Miller to give the EACTS Honoured Guest Lecture to talk about it. So it would not be fair for me to extend any more on this.

8. Cardiac transplantation

Another spectacular field in cardiac surgery was explored by Christian Barnard after his unexpected first heart transplantation, done on 3rd December 1967, in South Africa. He performed his second and first world successful heart transplantation a month later [199]. His success was based on the extensive research and work previously done by Norman Shumway at Stanford and by Richard Lower at Richmond [200].

The ethical, intellectual and psychological objections about heart transplantation soon started to disappear. The most well-known surgeons in the world seemed to begin a competition, so as not to be left behind. Shumway, Kantrowich, Cabrol, Grondin, Ross, Cooley, DeBakey and other groups, started their programmes in 1968. As many as 101 heart transplants were performed by 58 different groups in 1968. Soon afterwards, the initial enthusiasm started to vanish because results were very poor and disappointing, until almost all centres stopped their programmes in 1970 [201]. Despite general disillusion, Shumway’s team at Stanford, persevered with a serious research programme and continued clinical trials under systematic scientific approach criteria [202,203].

The introduction of cyclosporin A, as a new potent immunosuppressive drug, brought back the enthusiasm for cardiac transplantation. Roy Calne in Cambridge, proved the benefits of cyclosporine A in the experimental laboratory [204]. In 1978 it was clinically used for the first time in renal transplantation, confirming the improvement in graft survival [204]. Very soon afterwards, it was used for cardiac transplantation with a significant improvement in survival. Cyclosporin was successfully used to prevent rejection in experimental heart–lung transplants by Bruce Reitz at Stanford. This positive result encouraged the Stanford group to attempt their first clinical heart–lung transplant, which was successfully performed in March 1981. Five consecutive patients were operated upon with four long-term survivors, being able to achieve, after many years of perseverance and
hard work, one of the most important challenges in cardiac surgery [205].

Paediatric heart transplantation was initiated at Stanford in 1986 [206]. The same year Leonard Bailey at Loma Linda University performed the first successful new born heart transplant [207], opening an alternative to treat neonates with complex congenital conditions, such as hypoplastic left heart syndrome and other indications [208–211].

Continuous improvement in techniques, pre- and post-operative care, preservation of the donor organs, distant procurement and immunosuppressive therapies made heart transplantation a standard therapy. Many centres around the world started new programmes. The immediate consequence of such a flourishing success was the limited availability of human heart donors. The use of ventricular assisted devices such as bridges to transplant, is progressively becoming a practical long-term alternative to cardiac transplant, encouraging the development of new cardiac replacement devices [212,213]. Rainer Korfer in Bad Oeynhausen, Rolan Hetzer in Berlin and Daniel Loisance in Paris, are some of the groups in Europe, with the most important experience for long-term implantation of cardiac assist devices.

Another limitation of heart transplantation is the cardiac graft vasculopathy, which is the major cause for chronic allograft dysfunction and mortality [214]. Clinical strategies inducing tolerance to graft antigens may reduce chronic graft dysfunction in the future. Xenotransplantation is obviously one of the most attractive solutions, but progress has been slow and disappointing, with scarce hopes for clinical application in the near future inspite of some optimistic views [215,216].

Other alternatives to cardiac transplant have been introduced. One is the ‘skeletal muscle cardiomyoplasty’ for ventricular assistance, first applied to man by Carpentier and Chachques in 1985 [217]. Clinical trials have shown symptomatic improvement in some patients [218], but without proven improvement in the ventricular function [219]. It seems that the only benefit obtained with such operations could be to limit the progressive dilatation of the ventricle. Another approach to treat end-stage heart disease, that made a big impact, was the ‘partial left ventricular volume reduction’, proposed by Batista [220,221]. Multi-centre evaluation of this procedure has failed so far to make definitive conclusions. Inspite of a few good results, high early and late failures preclude the widespread use of such a procedure [222,223].

9. Arrhythmia surgery

Lillehei in 1957, developed the first small portable pacemaker, which was used to pace patients with an electrode implanted during surgery [224]. But it was Ake Senning who, in 1958 (8th October), implanted the first permanent pacemaker, to treat a patient with complete atrio-ventricular block [225]. The great technical advancement in the pacemaker industry expanded the possibility of pacemakers in bradiarrhythmias to more complex forms of bradi-tachyarhythmias, and even the use of implantable cardioverter defibrillators developed by Mirowski, to treat cardiac death secondary to severe ventricular arrhythmias [226].

Intractable tachycardia, secondary to WPW syndrome was first surgically treated and cured by interruption of the accessory pathway by William Sealy in 1968, at Duke University, in North Carolina [227,228]. Soon afterwards, all the different pathways of localizations were capable to being interrupted [229,230].

In Europe, Gerard Guiraudon in 1978 performed the ‘encircling endocardial ventriculotomy’ for the treatment of malignant postinfarction ventricular tachycardias, and later developed cryo-ablation techniques [231]. In America, Harken treated such patients with a surgical endocardial resection [232]. Vincent Dor, from Monato, performed an extended endocardiectomy associated with left ventricular reconstruction, with very good results [233].

James Cox, in 1982, at Duke University and later at Washington University, developed the Maze operation to treat atrial flutter or atrial fibrillation [234,235]. More recently, less aggressive surgical methods using radiofrequency catheter ablation have been successfully used by Joao Melo in Lisbon, as well as by other groups [236]. Radiofrequency catheter ablation has, at the present time, almost eliminated surgery for WPW syndrome and many other forms of supra and ventricular arrythmias [237].

10. Coronary artery surgery

One of the most important issues in cardiac surgery was the beginning and the later development of direct coronary artery surgery. Bailey was the first to perform, in 1956, a right coronary endarterectomy without cardiopulmonary bypass [238]. In 1958, Åke Senning was the first to do a coronary angioplasty with a vein patch [239]. Donald Effler in 1962, operated on the left main coronary artery using Senning’s technique [240]. But it was not until 1967 that direct coronary artery surgery started to developed, when Rene Favaloro with Donald Effler at the Cleveland Clinic started the aorto-coronary vein graft bypass operation [241,242]. Together with Dudley Johnson from Milwaukee, they were the leaders to promote and spread such procedures all over the world [243].

The following year, George Green started the clinical use of the internal mammary artery for coronary artery bypass with microvascular techniques [244]. But it seems that it was Vasili Kolesov from Leningrad in 1964 who was the first to perform this operation without extracorporeal circulation [245,246]. Coronary artery bypass surgery became the most frequent heart operation performed since then.

Carpentier, in 1971, used the radial artery as an alternative conduit for coronary revascularization [247,248], but patenty
rates were poor, so the procedure was abandoned. Neverthe-
less, later in 1991 Christian Acar began to use it again with
good results, with the revival of the radial artery for coronary
artery bypass grafting [249]. Other conduits were introduced
such as the right gastroepiploic artery [250] and the inferior
epigastic artery [251].

Surgery for complication of myocardial infarction, was
parallely developed. Cooley was the first to repair postin-
farction ventricular septal defect and postinfarction ventri-
cular aneurysms [252–255]. Latene and Vincent Dor have
introduced technical modifications to achieve a more
physiological reconstruction of the left ventricle cavity
[256,257].

One of the most revolutionary scientific achievement in
the treatment of coronary artery disease was the introduction
of the percutaneous coronary artery dilatation by Andreas
Grüntzig in 1974, in Zurich [258]. The method began to be
used widely and continuously improved, converting coronary
angioplasty to the most frequent procedure performed
and competing with coronary bypass operations.

Indirectly, as a result of the tremendous growth of interven-
tional cardiology in coronary artery disease, cardiac surgery
started to move in the direction of offering less invasive surgi-
cal procedures. Federico Benetti from Argentina was the
pioneer of coronary bypass techniques without pump [259],
and was responsible for the advent of the minimally invasive
direct coronary bypass grafting (MIDCAB). Another alterna-
tive was the limited access surgery on pump with the Port-
access techniques applied to coronary surgery [134].

In Europe, Antonio Maria Calafiore introduced the left an-
terior small thoracotomy procedure (LAST) [260],
followed by other groups with good results [261,262]. Tech-
nical difficulties associated with limited access to the heart,
brought back the full sternotomy approach and the perform-
ance of multi-vessel off pump coronary artery bypass
grafting (OPCAB) [263].

Beating heart surgery, has caused much criticism, doubts,
comments and concerns about the safety and efficiency of
such procedures [264]. But the introduction of new retrac-
tors with heart stabilizing devices, such as the one devel-
oped by Borst and Jansen [265], have favoured and
progressively helped spread the practice of beating heart
surgery [266,267]. Numerous publications not only show
safety and efficacy of the procedures with apparent immedi-
ate advantages, but also generally show reduced numbers of
graft per patient with less primary complete revasculariza-
tion [263]. Randomized studies comparing OPCAB with
conventional coronary surgery are still necessary, before
outlining the advantages and optimal indications of beating
heart surgery.

Myocardial revascularization using robotics, has emerged
in the last few years, allowing surgeons to perform endo-
scopic coronary artery bypass grafting (ECABG). The two
systems currently in use have been developed in America,
but have been applied first in Europe, by Carpentier in Paris,
in 1998 [268], Mohr in Leipzig [269] and Reichenpurner in


Munich [270]. Ralph Damiano has been the pioneer of
robotically assisted endoscopic coronary surgery in the
United States, after the FDA approval [271]. Total robotic
endoscopic coronary bypass grafting is slowly growing but
will require further developments and new fully dedicated
specialized surgeons. As Floyd Loop said in his EACTS
Honoured Guest Lecture, in Brussels in 1998, the last
decade marked the end of the beginning for coronary artery
surgery, not the beginning of the end [272].

11. Closing remarks

Cardiac surgery is where it is today, thanks to the imagi-
nation, sacrifice, perseverance and plain stubbornness of all
these bright men and many others. Young surgeons must be
prepared to keep this spirit if they are to succeed and expand
cardiac surgery even more in the future. But let me end my
lecture with a few chosen proverbs that, in their simplicity,
could convey some messages.

The artist is nothing without the gift, but the gift is
nothing without work – Emile Zola

I find that harder I work, the more luck I seem to have
– Thomas Jefferson

The wind and the waves are always on the side of the
ablest navigators – E. Gibbon

Well done is better than well said – Benjamin Franklin

Anyone who has never made a mistake has never tried
anything – Albert Einstein

Success usually comes to those who are not too busy
to be looking for it – Henry David Thoreau

And finally

Wise men make proverbs, but fools repeat them –
Samuel Palmer

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