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**AN EBOOK ON
VASCULAR DISEASES**

Coronary bypass evolution

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Abbreviations: CEC: Extracorporeal Circulation; OPCAB: Coronary Bypass without Circulation; MIDCAB: Less Invasive Direct Coronary Surgery; MINI OPCAB: Direct Coronary Surgery Less Invasive for Lower Sternotomy; ROBÓTICA: Use of the Robot to Assist in Surgery; TCT: Cardiovascular Transcatheter Therapeutics

Abstract

Alexis Carrel won the Nobel Prize for his contributions to vascular surgery in 1912. Many ways were tried to bring blood to the heart with the criterion of increasing coronary flow indirectly, such as resection of the sympathetic or radiation among others. Until, in 1935, Beck published 1 patient who had made a pedicle with the pectoral muscle, placing it on the myocardium in 1953 in Canada, William Mustard unsuccessfully attempted the first Direct coronary surgery in a human being. The first bypass or direct coronary bridge successfully in humans and clearly documented was performed by Robert Goetz at Van Etten Hospital in New York on May 2, 1960. For 1969 Favaloro and Johnson published a great experience using the saphenous vein. In 1978 Benetti et al started developed the OPCAB operation in different arteries and clinical situations, in January 1994, an 84-year-old patient came to see me in my office in Buenos Aires, Argentina, who was in very bad general condition and had a severe lesion in the anterior descending artery. We used for the first time endoscopy to dissected the mammary artery but we put a vein graft in this first case. In April 1994 we completed the first MIDCAB operation in the World with the 5 components Small incision, ideal conduit the left mammary artery, without extracorporeal circulation, without manipulating the aorta, without invading the pleura cavity. These operation open the new era of Minimally invasive coronary Surgery. Also in 1997 we did the First Ambulatory Coronary Surgery. Thought the Xiphoid Approach (Mini OPCAB Operation). In 1998 Didier Loumet perform in Paris the first coronary bypass assisted with a Robot. With these and others contributions and the work of many people the Coronary Surgery was Stablished. Every effort that can be made in the field of coronary heart disease is always small. The correct implementation of prevention and education programs from early childhood is where the great effort should go. But the reality is that, to this day, coronary heart disease remains the leading cause of mortality in most of the world's developed countries. Therefore, we must continue putting effort to improve and create new techniques and technologies to alleviate this real scourge of our time.



Introduction

Massaging the heart, the dog was kept alive, but died 2 hours later. This was enough to demonstrate that a bypass to a coronary artery was experimentally possible. This was part of Alexis Carrel's story. He won the Nobel Prize for his contributions to vascular surgery in 1912 [1].

Many ways were tried to bring blood to the heart with the criterion of increasing coronary flow indirectly, such as resection of the sympathetic or radiation among others [2-5]. Until, in 1935, Beck published 1 patient who had made a pedicle with the pectoral muscle, placing it on the myocardium [6,7].

Subsequently, Beck and Bailey revascularized the coronary sinus by placing a bypass with arterial blood in the venous circulation [8].

Arthur Vineberg, a Canadian surgeon, in 1946 developed the technique known by his name which consists of the placement of the internal mammary artery, performing a tunnel in the myocardium, without performing a direct anastomosis with the coronary arteries [9].

Vladimir Demikhov in Russia in 1952 continued the first investigations of Alexis Carrel, and for the first time he obtained survival with a dog to whom he made a direct anastomosis of the left internal mammary artery to the left coronary artery [10]. Murray and his group also conducted extensive experimentation in those years [11].

In 1953 in Canada, William Mustard unsuccessfully attempted the first Direct coronary surgery in a human being [12].

Charles Bailey, performed the first coronary endarterectomy in a human being, at the Hahnemann hospital in Philadelphia in October 1956, it consisted of directly unblocking the coronary artery, removing the atherosclerosis plaque that produced the stenosis [13].

William Longmire was performing a coronary endarterectomy and having problems with the artery was forced to perform a bypass between the left internal mammary artery and the right coronary artery. subsequently, according to his story, he treated 5 patients by performing similar bypasses, although he did not include them in his 1958 publication. [14].

In 1959 in Paris, Dubost performed using extracorporeal circulation, a direct reconstruction of the ostium of the left coronary artery due to syphilitic aortitis [15].

The first coronary bypass successfully in humans and clearly documented was performed by Robert Goetz at Van Etten Hospital in New York on May 2, 1960. The surgery was performed on a very symptomatic 38-year-old patient, used a cannula modified to connect the right internal mammary artery to the right coronary artery using a suture-free technique, this first documented bypass of history was studied with an angiography at 14 days which confirmed its permeability. The patient remained asymptomatic for one year, then started with angina pectoris and died on June 23, 1961 from a myocardial infarction.

Goetz was strongly criticized by his colleagues, so much so that, despite having carried out the operation experimentally on several occasions, he never again made a coronary bypass in a human being. Undoubtedly, the knowledge of this first patient in the USA and its publication in 1961 in the JTCVS (Journal of Thoracic and Cardiovascular Surgery) motivated several sur-

geons in various centers around the world to think about this new alternative to resolve the coronary obstructions [16].

In 1961, Senning first used a saphenous vein patch after performing a coronary endarterectomy. The interesting thing is that this is the first patient in the world who had a previous coronary angiography [17]. Previously, all surgeries were performed based on the medical history, electrocardiogram and manual palpation of the coronary arteries during the intervention

David Sabiston makes the first saphenous vein bypass to the right coronary artery at Duke University in 1962. The patient died after 3 days in the postoperative period, despite the great impact in the field of cardiology in the USA, Sabiston published this first case only in 1974 [18].

A situation similar to the previous one occurred with Garrett, Dennis and De Bakey in 1964 who after a coronary endarterectomy and due to difficulties in the procedure, performed a bypass with a saphenous vein to the anterior descending artery of the left coronary artery, this case was published 7 years after the operation and the bypass was open [19].

The report is that this patient was going to have a coronary endarterectomy and they were forced to place a bypass of saphenous vein between the coronary and the ascending aorta, due to difficulties in the original procedure in 1964.

In Houston in those years an extensive experimental work was performed, and this was well known to the surgeons of the time who constantly visited that center. Spencer performs an anastomosis with the left internal mammary artery to the anterior descending artery for the first time; using a suture for the anastomosis with extracorporeal circulation in the USA, which would be the first coronary bypass performed in the world using Extracorporeal circulation and published in the Journal of Cardiovascular Surgery [20]. In February of the same year, Kolesov in Russia initially connects the left internal mammary artery with the left coronary artery by a broad left thoracotomy without the use of extracorporeal circulation. His son Eugene showed me the original drawings in 1996 of all the instruments he used at that time. David Jones clearly explains how the events happened [21]: He recounts that when Kolesov [22] submits his first manuscript in November 1966 to the Journal of Thoracic and Cardiovascular Surgery, the editor at the time, Brian Blades, sends the work to Donald Effler for comment. It is clear that there were many surgeons thinking about how to perform this direct surgery in various ways. Five years had passed since the first patient Goetz had performed in 1960 and published in 1961. In addition, saphenous vein bypass were already used in other territories of the body.

Undoubtedly, the great impulse to direct coronary surgery begins when Mason Sones performs the first coronary angiography occasionally in the Cleveland Clinic and with his contributions and those of Melvin Judkins, diagnostic coronary angiography was established. This allows to be able to operate with anatomical precision and, in this way; the correlation between the anatomy and the different clinical situations begin to understood more the coronary disease [23].

By 1964, the study of many patients by Sones at the Cleveland Clinic encouraged Effler, Groves and Favaloro to intervene patients with the Vineberg operation, with which they acquired great experience. [24] Favaloro, who surely knew of the published works, and especially of this one by Kolesov, through his mentor Donald Effler, later said that he had learned about the

saphenous vein bypass of vascular surgeons who used them to repair renal stenosis. The fact that he was not the first to perform a coronary bypass does not take away any merit, because thanks to his contribution to systematize the technique from the Cleveland Clinic, the coronary bypass surgical technique with saphenous vein was established in the world from the first operations in 1967 [25]. For 1969 Favalaro and Johnson published a great experience [26,27]. Other important contributions published in 1968 were those of Green and Bailey using the left internal mammary artery in direct coronary surgery with different techniques. By 1971 there were about 10,000 patients undergoing direct coronary surgery in the considered 16 best centers in the world with a mortality of 10%. All these patients had been operated using extracorporeal circulation. As we know, it consists in replacing the functioning of the heart and lung during the operation and allows to operate with the heart completely stopped. The popularization of the technique gave rise to the first studies such as, the Veterans, cooperative study, the European coronary study and the Cass or coronary study. Although these initial studies in many situations did not show superiority of direct coronary surgery compared to medical treatment but they were the foundational basis for seven meta-analyses that clearly showed the superiority of direct coronary surgery over medical treatment.

In 1978 we had a patient at the operating table in one of our center in Rosario, Argentina, with the extracorporeal circulation prepared. I had already performed the purse string to perform the arterial cannulation, to connect the patient to it. Without using the extracorporeal circulation and with a beating heart, I decided to occlude the anterior descending coronary artery with a 3-0 suture, and I saw that the patient tolerated it very well. Then I proceeded to perform the anastomosis of the saphenous vein with a 6-0 polypropylene suture. Then, once the distal anastomosis was finished, I connected it to the ascending aorta. This was my first patient where I performed a coronary bypass without CEC. That same day, then, I operated on another patient with CEC. I remember well that the anesthetist told me that the first patient had been extubated and did not seem to have had surgery. Thus, in 1980 I made the first publication about seven patients, where three received a bypass to the right coronary, three to the anterior descending artery and one received a double bypass to the right coronary and anterior descending artery of the left coronary. All were intervened through sternotomy. The surgical mortality of this series was 0%. The average time of surgery was 80 minutes. I published this initial experience in the magazine of the Argentine Federation of Cardiology Benetti, FJ., (1980) [28], I presented it at the XII Chilean Congress of Cardiology and also at the University of San Pablo, Brazil. At that time, I was certain, based on this initial experience, that the segmental ischemia of a coronary artery with a critical injury for a limited period of time did not change the muscle viability if this was followed by reperfusion. In that first experience, we envisioned the possibility of performing this surgery in severe patients, since we observed that the postoperative period was faster and safer. We thought in 1980 that in the future it would be possible to reduce costs with this type of operation, and that with development it could be applied to all branches of the coronary arteries. Posteriori we demonstrate the concept that the myocardium did not suffer during temporary coronary occlusion by performing all kinds of measurements, including myocardial biopsy before and after the coronary bypass was connected. We demonstrated by 1984 that we could operate patients during an acute myocardial in-

farction and with the bypass placement, stop the progression of the thrombus or part of it, and prevent or decrease its migration to the coronary distal circulation. In this way, the number of hours of the intervention could be extended and, in many cases, completely recover the heart muscle [29,30]

With Massimo Mariani and Carlos Ballester, we publish the results, far from this initial experience, in surgery of acute myocardial infarction without extracorporeal circulation [31]. The first patient we performed direct coronary surgery without the use of extracorporeal circulation, 41 years after these operation today is alive and asymptomatic. In 2006, a multislice tomography was performed, and the venous bypass was open.

The reality is that I did not know that some of the first patients who had had a coronary bypass were operated without extracorporeal circulation.

Several years later, in 1988, I traveled to USA and visit several centers showing our experience which led surgeons such as Michael Wood, Pablo Zubiato, Raphael Mohr, among many others, coming to Buenos Aires to train to immediately Start doing it [32].

I culminated that trip in a meeting in San Diego. Denton Cooley and John Kirklin were interested in my work and wanted to know more details about the surgery. Johnin that time was the editor of the JTCVS and I had posted a paper comparing costs between this surgery and angioplasty in a group of patients [33]. Cooley, in response to a Super 8 movie that I had sent him showing ouer technique without CEC, writes me a letter commenting on the experience of Jay Ankeney, who had previously performed 143 cases with a similar technique without CEC [34].

Years later I had the pleasure of meeting Jay Ankeney in Washington and suggested that he try to bring his patients together and study them with a coronary angiography. And so, together with Daniel Goldstein, they published the results of these studies in 2007 demonstrating the long-term effectiveness of this operation [35]. The operation of coronary surgery with the heart beating and without the use of extracorporeal circulation was performed for many years without any type of technology, performing the same in all arteries of the coronary circulation The way to expose the heart to be able to do it was by placing different traction points in the pericardium that allowed us to expose the surface to be treated. Various incisions were used in addition to the middle sternotomy, such as anterolateral thoracotomy (using the ascending aorta for the proximal bypass anastomosis), or the posterolateral thoracotomy (performing the proximal anastomosis to the descending aorta). These approaches were used according to the clinical and anatomical variants of each patient. It should be noted that 95% of the patients in our series in the 1990s were intervened for medium sternotomy. As I said before, in 1980 the presentation of our first patients was made in São Paulo, Brazil, and several local surgeons began to perform the technique, but without any doubt Enio Buffolo in São Paulo was the one who began to develop it in parallel with us [36]. Later Ricardo Lima in Recife, contributed with improvements in the technique to expose the heart [37]. In Brazil and Peru it became a routine operation.

In 1991 we published the experience of 700 patients undergoing direct coronary surgery without the use of extracorporeal circulation in Chest Magazine, and this led to more surgeons becoming interested and coming to Buenos Aires and São Paulo

to train. In those years, most coronary surgery operations were performed with cardiopulmonary bypass and stopping the heart [38]. Coronary surgery was performed using mostly saphenous vein as a conduit in the bypass and in 1971 Alain Carpentier began using the Radial artery for the first time [39]. In 1975 a survey was carried out that included 400 surgeons, with a total of 41,000 patients operated, 100% of surgeons performed surgery with extracorporeal circulation and 6% used the left internal mammary artery as a conduit in the coronary bypass, the rest used The saphenous vein. In those times there was divergence in the technique of protection of the heart and the technique of venting it. Suma and Pym proposed the use of the Gastroepiploic artery [40,41] and Vincent and Puig, the epigastric artery in the 80s as alternative ducts. [42,43] Subsequently, several surgeons following Barner's initial experience [44] such as [45,46] and Tector (who systematized the technique) [47], began using arterial conduits to perform Direct coronary surgery. Then, there were several contributions and variables, such as that of Prapas, and others with and without extracorporeal circulation using only arterial conduits [48].

The first steps in minimally invasive coronary surgery

In 1993 I was observing an abdominal laparoscopic surgery and I began to think that this was the way to perform a coronary bypass on an outpatient basis. Thus, in January 1994, an 84-year-old patient came to see me in my office in Buenos Aires, Argentina, who was in very bad general condition and had a severe lesion in the anterior descending artery. Then I proposed this new technique, which consisted of performing a dissection of the left mammary artery using video thoracoscopy without opening the pleural cavity and then performing the bypass to the anterior descending artery by means of a small incision under the left teat with the heart beating without use extracorporeal circulation. We performed the operation on January 31, 1994 in Buenos Aires. At the time of analysing the flow of the mammary artery I did not find it appropriate, and I placed a saphenous vein bypass between the coronary and the ascending aorta for that same incision. The patient tolerated the operation very well, this being the first time that thoracoscopy was used to dissect the mammary artery without opening the pleural cavity in a human being. In April 1994, also in Buenos Aires, we performed the technique without opening the pleural cavity, and we placed a bypass from the left internal mammary artery to the anterior descending artery with the heart beating and without the use of extracorporeal circulation. The patient tolerated the operation very well, it was found that the bypass worked very well and was discharged after 3 days. It was considered the first less invasive heart surgery in history, since it had 5 components:

- Small incision
- Ideal Conduit left internal mammary
- Without extracorporeal circulation
- Without manipulating the aorta
- Without invading the pleural cavity

In June we performed another mini invasive coronary surgery and the patient went Home at 36 hours after the intervention. The technique and the first experience was published in the Argentine Medical Press in that year, and in the Journal of Cardiovascular Surgery in 1995 [49-51].

The idea was to be able to perform bypass surgery on an out-

patient basis. I remember that in those days a consultant from the Medtronic company who had learned about this operation came to my office in Buenos Aires and I talked with him about all my experience, including how the heart area could be stabilized, when I did the sternotomy surgery where he sometimes used suction with 2 probes or alternatively a partial clamp. I also told him about the idea of emptying the tip of the heart to be able to pull it and achieve an exposure of the different faces of it. I gave him the book he had published in 1993 about how we did the technique and our first experience in 1000 patients undergoing coronary surgery without using extracorporeal circulation [52,53].

We also occasionally use a modified fork to stabilize the area We performed the coronary grafts without touching the aorta, when it was very calcified, connecting the left mammary artery to the anterior descending artery and the remaining grafts with a segment of saphenous vein connected to the right mammary artery for proximal flow.

In 1993 we conducted a live coronary surgery conference in Buenos Aires, due to the interested in Direct coronary surgery without the use of extracorporeal circulation. Several surgeons were present, among which was Tomas Salerno who invited me to a meeting in Chicago in October 1994 to present a Video with all my coronary surgery techniques without the use of extracorporeal circulation. In that video I also showed the operation with video thoracoscopy performed by a small left thoracotomy, without opening the pleural cavity and I said we had entered the new era of less invasive heart surgery. Of course, this generated great expectations.

The following month I travelled to Italy, to the University of Siena, where I operated on a patient with a left coronary artery lesion who had 3 arterial bypasses using video thoracoscopy and a small left thoracotomy without opening the pleural cavity. The reestudied of these patient showed the grafts open and the video of the operation was presented that week at a coronary surgery meeting organized at the Gemelli clinic in Rome. This produced a great impact among all the surgeons present and undoubtedly stimulated many subsequent technological developments [54-59].

In the same meeting Manny Subramanian presented his initial experience with mini thoracotomies without video. Just as Jan Gradjean and Pete Bonstra from the Netherlands presented their technique of performing a bypass with the gastroepiploic artery with a small abdominal incision, among other contributions.

The limitation for the dissemination of the coronary surgery technique without cardiopulmonary bypass was the lack of adequate technology, which I knew how to do it, but I don't have the possibilities to develop it. In January 1995 I attended a meeting in Palm Spring California, where I presented my experience, there I met Judie Vivian (CEO of Promedica, a prestigious prestige education company), and Sthepen Westaby (Oxford University surgeon) who propose to me to make a meeting in Oxford showing all the techniques with live surgeries [60].

Commenting on my concern to Judie Vivian about the development of technology in order to reproduce the operation on a large scale, she advises me to start a company in California, where we ended up founding together with Richard Ferrari and Chuck Taylor, Cardiothoracic System or CTS, with the important collaboration from Tom Fogarty.

CTS was the first company to develop technology for this operation, and allowed coronary surgery without extracorporeal circulation to be disseminated and cardiovascular surgeons trained worldwide. It is important to note that all my inventions were assigned to that company so I do not receive any kind of royalty.

In 1995 were less than 5,000 patients undergoing coronary surgery without the use of extracorporeal circulation worldwide [61]. Initially, we designed the technology for the operation of MIDCAB (That means Minimally Invasive Direct Coronary artery bypass).

This operation marked a new era of cardiac surgery, as Walton Lillehei said at the 1996 conference in the Parthenon looking at the Acropolis in Greece

We also immediately developed technology not only to stabilize the heart but also to expose the different areas of the heart to address all the branches of the coronary arteries.

In 1996, as I say we perform in Oxford the live conference without the use of extracorporeal circulation in vivo with the presence of a large number of surgeons from all over the world. For the first time I used a mechanical coronary stabilizer in a patient, assisted by David Taggart. In 1998 we won with Chuck Taylor the R / D of the Academy of Sciences and Arts of Chicago for the invention of the stabilizer

The stabilizer, either mechanical or by suction, allows to leave the area semi-immobilized where the bypass is constructed. The technology developed, together with the intense training and education program for surgeons on all continents, and the contribution of other companies, such as Medtronic, was what allowed us to approximately 46% of Direct coronary surgery at ASIA, 20 % in the USA and 15% in Europe will be carried out without the use of extracorporeal circulation by the year 2000 and established the technique .

In 1996 I had the opportunity to experimentally use the first Robot in California from the Intuitive company. As of 1998 it was first used to assist coronary surgery in humans by Didier Loumet [62]. Recently published there are 28 studies where the Robot was used for cardiac surgery in 5993 patients, it was mainly used for coronary surgery and mitral valve surgery, also to close atrial defects or tumours, with excellent results.

The biggest limitation at the moment is the high cost, but new types of simpler robots are already on the market and certainly in a few years, they will reduce the costs of the procedure and make it more reproducible.

In October 1997 I was ready to perform a MIDCAB operation using 3D Video Endoscopy in a 76-year-old woman, she had a very long xiphoid appendix with characteristics that allowed me to dissect the mammary artery and be able to perform the Bypass to the anterior descending artery, without open the sternum. This technique, less invasive, allowed the patient to be discharged with 22 hours of hospitalization, this being the first patient in the world who underwent direct ambulatory coronary surgery [63]. We performed the second outpatient with Máximo Guida in Venezuela. This is how I described this new technique called XIPHOID APPROACH, for this first operation

Actually, as very few patients have this anatomical variant, and in the vast majority it is necessary to open the lower part of the sternum, today we call it the MINI OPCAB operation (. Both techniques, the MIDCAB and MINI OPCAB, are now performed routinely in several centers and their growth is planned directly or assisted with Robot, especially as an alternative to HYBRID coronary surgery, That consists in most of the cases a Bypass of the Left internal thoracic artery to the anterior descending artery and stents in the other arteries. This MINI OPCAB technique has the advantage in our experience over the MIDCAB technique, that is better tolerated by the patient and allows its ambulation immediately even when several grafts are made (Figure 1-2-3) [64-68]. The original contributions of Charles Dotter [69], Oct undoubtedly opened the way for Andreas Grunzitz [70] to develop balloon angioplasty to dilate the coronary arteries, and Julio Palmaz the stent [71]. This radically modified the treatment of coronary heart disease. A large number of patients who in the past underwent coronary surgery are currently treated with stent angioplasty. Many studies have been carried out comparing the treatments between surgery and angioplasty with the placement of stents, the Syntax study is the most conclusive so far, from the practical point of view for the general practitioner and the cardiologist, to be able to make a decision with your patient.



Figure 1: Incision MINI OPCAB Operation

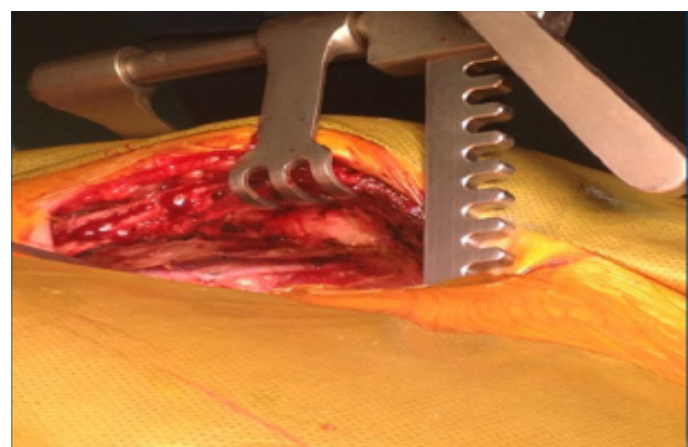


Figure 2: Left internal mammary dissection MINI OPCAB Operation

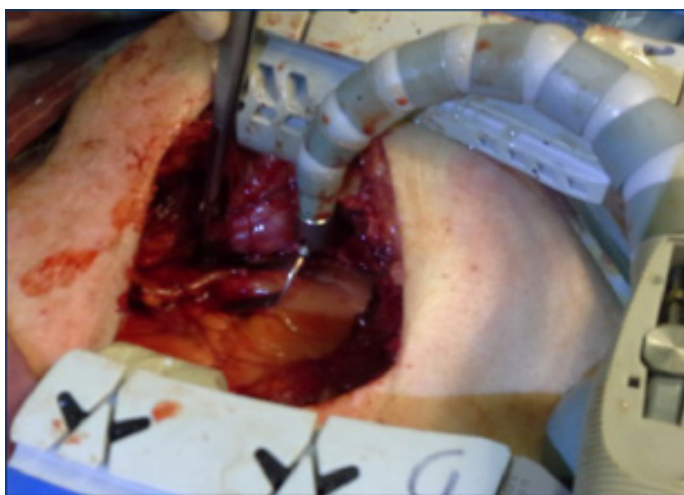


Figure 3: Anastomosis left internal mammary to the left anterior descending artery with mechanical stabilizer and special retractor

In this study, bypass or coronary bypass surgery was compared with drug-eluting stents. 85 centers were selected, 62 European and 23 in the USA. Patients with arteries less than 1.5 mm and lesions less than 50% were not included in the study. It was established that the sponsors would do the data collection, as well as the biostatistical evaluation and the publication of the results would be in charge of the researchers. The study was approved by the ethics committee of all participating Hospitals. The study sponsor was Boston Scientific Corporation with a cost of 50 million dollars. The patients initially considered for the study were 3075, of which 1275 were rejected to enter the randomization registry due to the complexity of the lesions; which excluded a significant percentage of patients that we see daily in real life and that many can benefit from coronary surgery without cardiopulmonary bypass or combined treatments. We know based on our experience of more than 47 years treating patients with coronary heart disease that, for approximately 60% of the general population, cardiac survival if they do not have another disease will be given by the anterior descending artery heals fundamentally or by a permeable left mammary artery bridge or bypass connected to it. For 15%, a large right coronary is going to be fundamental for their survival. And the rest is given in general by a great anatomical variability. Therefore, the approach to this disease is so heterogeneous that it is impossible to establish fixed patterns. The treatment always depends on many circumstances, the most important being, I insist, the experience of the working group in that particular center. With which it is necessary to consider all type of study or the guides always indicative.

In this study by Syntax, in patients undergoing surgery, 3.2 bypasses or bridges were performed per patient, but complete revascularization with bypasses or arterial bridges was achieved in only 18.9% of patients. In the percutaneous treatment group, the average was 4.2 stents per patient. In the group that received coronary bypass or bridge surgery: 97.3% received an internal mammary artery, 27.6% double internal mammary, 78.1% mammary plus saphenous vein, 14.1% used the radial artery. Only bypasses or venous bridges were used in 2.6% of patients. Only 15% of the patients in this study were operated without the use of extracorporeal circulation. The results of 1275 patients per year were analysed, where the incidence of infarction was 4.2% for the stent group vs. 2.5% for the surgery group. In short, 1/3 of the operated population, a year showed better results with surgery but it is important to note that,

for the first objective of the study of death or serious adverse events, non-inferiority was not demonstrated by percutaneous treatment. Clearly, the bypass or coronary bridge was superior for most of the patients in the study. At 4 years of follow-up, the significant difference between the two study groups in the incidence of cerebral vascular accidents disappears. That clearly in the surgery group was higher, because 85% of the patients were operated with extracorporeal circulation and manipulating the ascending aorta (as we know fundamental factors in the possibility of its appearance) [72].

However, it was established that in patients with a Syntax score of less than 22%, the stent is as safe as surgical revascularization. At 5 years of follow-up, the mortality for surgery was 9.2% vs. 14.6% for the stent group (P.0.006). The cause of cardiac death was 4% for surgery vs. 9.2% of the stent group (P.0.001). The incidence of a new myocardial infarction was 3.3% for the group of patients who received bypass or coronary bridge vs 10.6% for the group that received stents (P.0.001). The incidence of stroke at 5 years was 3.4% for the group of operated patients vs 3% in the group of patients who received Stents (P. 0.66), taking death in general, plus death of cardiac origin, plus death by infarction, for surgery was 14% vs. 22% for the group of patients who received coronary stents (P. 0.001). It is important to insist that 85% of the patients were operated with extracorporeal circulation. The group of operated patients received a new coronary revascularization in 12.6% of the patients and the group of patients who had stents in 25.4% (0.001). When one begins to see the different subgroups, such as patients who had left coronary artery disease, surprisingly it showed no significant differences between direct coronary surgery and stents. These data gave rise to new studies such as Xience Prime and Excel, among others, to clarify the situation that is ongoing. In any case, it is important to clarify that the SINTAX study clearly demonstrated at 5 years that in 65% of the patients who had a left Coronary Trunk lesion and a score greater than 32, the surgery obtained better results. Even in all patients with three-vessel disease and a score greater than 22%, in 79% the surgery was better.

We can conclude according to this study, which so far was the best designed, that patients who have a medium or high SINTAX score have better results with bypass surgery and for those at risk under the stent it is still a safe alternative [73-76].

But despite all the scientific evidence in randomized clinical studies, meta-analyses and guidelines confirming that coronary artery bypass grafting has better results, most patients continue to undergo percutaneous treatment, that is, angioplasty with Stents placement. In my opinion, the important thing is to use the best of both therapeutics according to the clinical situation of each patient and the experience and results of each work group.

Hybrid treatment of coronary heart disease opens an alternative for many patients, solving the problem of coronary obstructions less aggressively than conventional surgery [77-79]. The basis of this treatment lies in the ostensible advantage of the left internal mammary artery when it is used to bypass the anterior descending artery by means of a mini inferior sternotomy, and stent placement in the lesions of other coronary arteries.

The indications of this technique are performed in patients who are not good candidates for conventional bypass surgery:

- when the circumflex and right coronary arteries are of poor quality to perform a coronary bridge.
- when the aorta of the patient is very calcified being what is called porcelain aorta.
- when the ducts that should be used are not in conditions, for example, by important venous varicose veins that prevent the use of saphenous veins.

The Poem study, which we presented in the year 2000 at the TCT where the permeability and results of a bypass or bridge were compared with the left mammary artery to the anterior descending in 162 patients, who underwent a MIDCAB operation using the technology of CTS (Cardiothoracic Surgery), and 149 patients, who underwent conventional surgery with extracorporeal circulation, showed that there was no difference of any kind between the 2 techniques and that the permeability of the bypasses or bridges was equivalent. Seeing, at the first 6 months of the operation, there are obvious advantages in terms of reducing the hospital stay of patients undergoing the MIDCAB operation. It was established as the best option of the moment for patients who needed an operation of the left mammary artery to the anterior descending, by demonstrating results and permeability of the bypass or bridge similar to conventional surgery with less hospital stay. This study laid the foundation for the expansion of this MIDCAB operation as a variable for the concept of Hybrid coronary surgery [80].

Off pump coronary artery bypass (OPCAB) technique

In very high-risk patients, the OPCAB technique was favourable in groups with experience in both techniques. The incidence of atrial fibrillation in the postoperative period was lower in patients operated without extracorporeal circulation. We had already noticed this problem in our experience in the '90s when we compared our series of patients operated with and without cardiopulmonary bypass, and it is mainly due to the technique used. For 2010, when one analyses all the studies carried out in centres with surgeons trained in OPCAB, it can be concluded that this technique is still more effective in general terms in high-risk patients, elderly people with high frailty and with severe arteriosclerosis in the ascending aorta. There is a lot of disparity between the centres and the countries, where the role of the surgeon with adequate training is fundamental, and remains the most important variable when one compares both surgical techniques. A clear example is Japan, Korea, Taiwan, China, India and other Asian countries where we conduct extensive training of surgeons. In them, most coronary surgeries are performed without the use of extracorporeal circulation and the results are far superior to conventional coronary surgery. It is clear that advances in oxygenators and technology in the last decade have made the operation with extracorporeal circulation a safer technique than in the '90s.

The ART study, which compared the use of one or two mammary arteries, showed that there is no difference at 5 years if the patient is operated with or without cardiopulmonary bypass. However, the technique of not touching the aorta and not using extracorporeal circulation is superior to any surgical strategy and the results at 3 years are indisputable and superior when compared to the SINTAX study [72,81].

Although the Rooby trial showed a better overall result in 5 years in patients operated with extracorporeal circulation, it is a study that suffers from an initial failure, the group of surgeons performing OPCAB surgery did not have enough experience

with the technique. which makes it unreliable [82].

In any case, it is very clear that, in properly trained centres, long-term techniques do not show differences, as was demonstrated in the 5-year CORONARY study, with the potential advantages of surgery without extracorporeal for application in different patients, as we discussed earlier [83].

It is important to emphasize that less invasive coronary surgery without the use of extracorporeal circulation with any of the existing techniques (MIDCAB, MINI OPCAB, ROBOTICS) opens up a very promising outlook for the treatment of coronary heart disease.

Much has been discussed which is the ideal conduit to perform coronary bypass. We know the effectiveness of the left internal mammary artery when it is used for bypass with the anterior descending artery, being undoubtedly the best long-term operation. The use of 2 mammary it is the best option for many patients, if you do off pump and non-touching the ascending aorta.

Every effort that can be made in the field of coronary heart disease is always small. The correct implementation of prevention and education programs from early childhood is where the great effort should go. But the reality is that, to this day, coronary heart disease remains the leading cause of mortality in most of the world's developed countries; Therefore, we must continue putting effort to improve and create new techniques and technologies to alleviate this real scourge of our time.

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