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Heart surgery before the cardiopulmonary bypass era

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SOUHRN

Až do konce 19. století se na srdce nahlíželo jako na v jistém smyslu „nedotknutelný" orgán. V roce 1895 napsal známý chirurg Stephen Paget, že „výkony na srdci nejspíše dosáhly hranice nastavené přírodou, (protože) žádné nové metody a žádné nové objevy nedokážou překonat přirozené obtíže doprovázející poranění srdce". Nicméně chirurgové jako Axel Cappelen v Norsku v roce 1895 a Němec Ludwig Rehn se v roce 1896 odvážili vstoupit do této tabuizované oblasti a řešit bodná poranění srdce; tak začala éra kardiochirurgie. Později dvě světové války poskytly válečným veteránům, jakými byli George Gray Turner, Henry Souter, Dewitt E. Harken, Wilfred Gordon Bill Bigelow, Walton Lillehei, John Gibbon, Vasilii Kolesov, Nikolai Amosov, Christian Cabrol a mnoho dalších, četné příležitosti k hledání způsobů léčby poranění srdce. Na přelomu století nabyla revmatická horečka s endokarditidou téměř epidemických rozměrů; výsledkem bylo, že se postižení mitrální chlopně stalo běžnou komplikací. Intenzivní pátrání po chirurgickém řešení si vyžádalo dlouhou řadu experimentů, jež prováděli chirurgové Alexis Carrel a Tuffier v roce 1914, Elliot C. Cuttler v roce 1923 a sir Henry Souttar v roce 1925. Operace malého pacienta se syndromem modrého dítěte, kterou v roce 1944 provedli Blalock a Taussigová, prokázala, že výkony na srdci jsou možné. Za začátek moderní éry kardiochirurgie lze považovat rok 1953, kdy John Gibbon popsal metodu kardiopulmonálního bypassu (cardiopulmonary bypass, CPB). Dějiny inovací v kardiochirurgii v období před CPB tak představují fascinující součást dějin medicíny.

ABSTRACT

Until the late 19th century, the heart was thought as an organ that shouldn't be touched. Famous surgeon Stephen Paget in 1895 wrote: "Surgery of the heart has probably reached the limit set by the nature, no new methods, and no new discovery can overcome the natural difficulties that attend a wound of the heart." But surgeons like Axel Cappelen in Norway in 1895, and Ludwig Rehn in Germany in 1896 dared to enter into this taboo territory and repaired stab injuries of the heart. With these, the era of cardiac surgery began. Later, the two world wars opened the opportunities of exploring heart wounds for the war veterans like George Gray Turner, Henry Souter, Dewitt E. Harken, Wilfred Gordon Bill Bigelow, Walton Lillehei, John Gibbon, Vasilii Kolesov, Nikolai Amosov, Christian Cabrol and many others. At the turn of the century, rheumatic fever with endocarditis was almost an epidemic disease. Consequently, mitral valvular pathologies were common complications. The intense search for a surgical solution led to the valuable experimental works of Alexis Carrel and Tuffier in 1914, Elliot C. Cuttler in 1923, and Sir Henry Souttar in 1925. In 1944, Blalock–Taussig shunt designed for blue baby demonstrated that heart surgery could be possible. Finally in 1953 John Gibbon developed the cardiopulmonary bypass (CPB) technique with the heart lung machine commencing the modern era of cardiac surgery. The history of Pre-CPB innovations of cardiac surgery remains a fascinating part of the history of medicine.

Keywords:
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Introduction

The heart is a difficult organ for the surgeons to operate and it is considered the ultimate surgical frontier. Until the late 19th century, it was thought that heart is a sacred organ not to be touched by the surgeons. Legendary surgeon Theodore Billroth once said: "Any surgeon who dares to touch the heart of his patients, will lose the respect of his colleagues." Be it myth or truth, this Billroth verse is widely quoted in the contemporary literatures.[1] Another famous surgeon Stephen Paget in 1895 wrote: "Surgery of the heart has probably reached the limit set by the nature, no new methods, and no new discovery can overcome the natural difficulties that attend a wound of the heart."[2] But there were others, who were ready to take the burden. Surgeons like Axel Cappelen in Norway and Ludwig Rehn in Germany dared to enter this taboo territory and made attempts to change the course of cardiac surgery.

The nineteenth century efforts

The German surgeon Ludwig Rehn enjoys the credit of performing the first ever successful cardiac surgery in human history. On the 9th of September 1896, he repaired a stab wound on the right ventricle of a patient. But some confusion and controversy still exist in deciding the first cardiac surgery, depending on how it is defined. A few other claims are there to have achieved this accomplishment even before Ludwig Rehn. However, these surgeries either involved only the pericardium or the patients didn't survive justifying the credit being awarded to Rehn.

With the beginning of the nineteenth century, there came a few reports of surgery involving the pericardium. These procedures mainly were drainage of pericardial fluid accumulations through thoracic incision. In an 1815 publication, Francisco Romero from Barcelona claimed to perform such an operation as early in 1801, for which some authors consider him as the first cardiac surgeon.[3] Then a few cases of suturing on the true myocardium came. With a laborious effort Alexi-Meskishvili V, and Böttcher have enlisted 22 reported cases of suturing of the heart performed in the nineteenth century. Of them, only 8 survived.[1]

Norwegian surgeon Axel Hermansen Cappelen (1858–1919) attempted to repair a stab wound on the left ventricle of a 24-year-old man on the 4th of September 1895, at the Rikshospitalet in Kristiania, today's Oslo.[4] Having performed left lateral thoracotomy and extending the existing pericardial wound, an injury to a coronary artery became visible. This was tied with cat-gut sutures. On the first postoperative day, the patient could already eat again. However, the patient developed fever, and the patient died on the morning of 7th September. The autopsy revealed mediastinitis as the cause of death. It was also established that the ventricular wall had not been entirely penetrated, and that an injury to the coronary artery was the source of the bleeding.[4]

The next known case of heart suturing is that by Guido Farina (1868–1939) of Rome in March 1896. His repair of a stab wound on the left ventricle of a patient was mentioned only briefly in a contribution by Franceso Durantes to a discussion at the 11th Congress of the Italian Society for Surgery in 1896, It was not until 1910 that John Bland-Sutton reported this case in detail.[5] However, this patient also died of severe bronchopneumonia after 3 days, though autopsy showed a perfectly healed cardiac wound.

Another case remains mysteriously obscured in most of the literature. Daniel Hale Williams, an African American surgeon performed what is often referred to as the first successful cardiac operation.[6] On the 10th of July 1893, Williams repaired the torn pericardium of a knife wound patient, James Cornish. About fifty days after the initial procedure, Cornish left the hospital. It was not reported until 1897. Some contemporary literature claims that the repair involved injury of the right ventricle as well. However, on most accounts Williams is only given credit of performing pericardial repair as the first African American surgeon in 1893, whereas Henry Dalton was the first American to perform pericardial surgery on the 6th of September 1891.

The surgical repair by Ludwig Rehn qualifies as the first successful cardiac operation in all regards. William Justus, a 22-year-old gardener in Frankfurt am Main, Germany had a knife wound to the chest in the night of the 7th of September 1896. Returning from a journey on the 9th of September, Dr Rehn saw the patient, who was earlier managed by his colleague Dr Siegel. Rehn attempted hemostasis with an incision in the fourth left intercostal space and dividing the fifth rib. After extending the pericardial cut, a wound measuring approximately 1.5 cm in the middle of the right ventricle could be seen in diastole. Rehn repaired the wound putting three interrupted stiches with a silk suture on a fine intestinal needle. After placement of the third suture, the bleeding completely stopped. The patient recovered and discharged later in good health.[7] This nineteenth century triumph ultimately changed the course of cardiac surgery and is rightly considered as the first ever successful heart operation.

The great wars and cardiac surgery

Then came the world wars. The development of heart surgery is one of the greatest achievements of medicine in the 20th century. The nineteenth century was the century of scientific inventions. Several new inventions in Europe and America had changed the world forever. At the same time, sheer competition and rivalry between the European colonial forces reached the peak. The result was the two all-time worst man-made catastrophes, the First and the Second World Wars took place in the 20th century with an estimated loss of more than a hundred million lives. Ironically, these heavy casualties created a unique opportunity for the surgeons to perform operations. As human tragedies, they were unsurpassable, but as for medicine, especially the new field of heart surgery, there was a boom.[8,9]

Most soldiers with heart wounds usually die before any medical attention on the battlefields from the immediate trauma, from shock or blood loss. But some of them survived the initial injuries with bullets and metallic fragments inside their hearts. Although it was still thought by

the medical establishment that nothing could be done, the world wars changed the attitude of physicians towards heart surgery forever. Dedicated surgeons working under desperate circumstances bucked conventional medical wisdom and found innovative ways to treat the heart wounds successfully.[9,10]

Dr. George Gray Turner made one of the earliest attempts to remove a bullet from a soldier's heart injured during the battle of Cambrai at a British base hospital. Fired from 500 yards, a machine gun bullet went through the victim's left breast pocket into the heart. This was the time before the introduction of blood bank, pacemaker, and antibiotics. He performed the surgery just with primitive ether anesthesia and poor OT lighting. This lucky first world war (WW I) soldier, who was operated in 1917, survived and subsequently lived through to participate also in the second world war (WW II).[8,9]

The first documented series of successful cardiac operations were performed in 1944 by US Army surgeon Captain Dwight Emary Harken in Europe. The amazing series of 134 operations for removal of shrapnel pieces and other projectiles in and around the heart, right after D-day and the battle of Omaha beach, can certainly be considered as one of the decisive turning points towards modern cardiac surgery. Advances have often been war related and the fact that the patients were young, otherwise healthy soldiers, certainly favored successful results. It probably led to the beginning of surgery for mitral stenosis. One should nevertheless remember that the 1948 breakthrough in surgery for mitral stenosis did not happen out of the blue, as a short historical retrospective will show.[11]

Early surgical ventures and adventures

Dr. Henry Souttar was a veteran British military surgeon of WW I. At the outbreak of war in 1914, Souttar was deployed to the Belgian field hospital at Antwerp and for his performance, was awarded the Order of Crown of Belgium. After the war, he innovated a surgical treatment for mitral stenosis (primitive CMC). On the 6th May 1925, he made an opening in the left atrial appendage of the beating heart and inserted a finger to correct the damaged mitral valve (transauricular finger dilatation). This was a pioneering operation, improved the patient's condition, who survived five more years.[5,11] Souttar was certainly an experienced surgeon as he managed, under 1925 conditions, to take hold of a torn auricular appendage and instantly still a massive hemorrhage, ligating the appendage at its base. Souttar was spared the unfortunate experience of Cuttler with his six consecutive operative failures. Twenty-five years later, when Harken asked him why he never followed up his initial success, he wrote back "because I could never get another case". At the time, it was the doctrine of cardiologists that what mattered the condition of myocardium, not the stenotic valve.

After the war

The two world wars opened the opportunities of exploring heart wounds for the war veterans like George Gray Turner, Henry Souter, Dewitt E Harken, Wilfred Gordon Bill Bigelow, Walton Lillehei, John Gibbon, Vasilii I. Kolesov, Christian Cabrol and many others. The second world war ended on 15th August 1945. In the European front, it ended even earlier in May 1945. The surgeons engaged in different warfronts returned home and joined civilian hospitals. American surgeon Clarence W. Lillehei served in Africa and Italy during the second world war. He won several combat medals, including a Bronze Star for meritorious services and achieved the rank of lieutenant colonel. After the war, he returned to the University of Minnesota in 1945 and later he was inspired to perform the historic operations with hypothermia and inflow occlusion (Fig. 1), of atrial septal defect (ASD) closure, along with his longtime friend and colleague, F. John Lewis.[12]

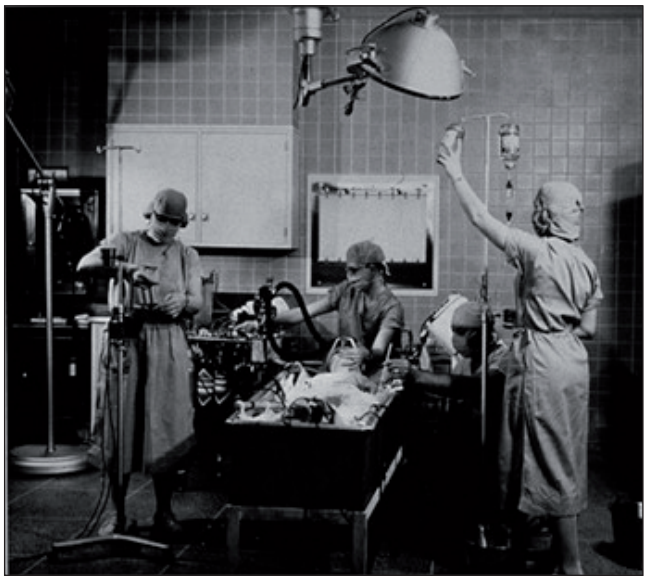

Fig. 1 – The patient is put inside an ice filled tub for surface hypothermia with inflow occlusion technique.

Two most innovative techniques

'Surface hypothermia with inflow occlusion' and 'Controlled cross circulation' were two most amazing innovative techniques of heart operations invented by the surgeons before the CPB era. The extreme cold climate of Canada and Northern USA inspired the surgeons to make the use of the freezing temperature in reducing metabolism for tissue restoration while the heart is kept arrested for the intracardiac repairs. The anesthetized patients were put in a tub full of ice and cold water and let the body proceed to hypothermia. When the body temperature had gone down near 28 °C, the heart would have gone to fibrillation or arrest. The hypothermic body was then rapidly taken to operation table and the cardiac operation was performed in a quick mode. Hypothermia reduced the oxygen requirement of the body during the period of circulatory arrest and protected the sensitive organs, especially neuro tissues. On completion of the surgical correction, the body was shifted to another tub full of warm water for rewarming and restoration of cardiac function.[13]

Canadian war veteran surgeon Wilfred Bigelow played a key role introducing the idea of hypothermia in cardiac operations. Based on these results, the method began to be used in clinical cases. John Lewis in Minneapolis was the first to succeed. On the 2nd September 1952, he and Richard Varco closed an atrial septal defect through a wide atrial incision during an inflow-occlusion.[14]

Legendary Indian Bengali surgeon P. K. Sen performed the first intracardiac repair of an ASD in India using this technique in 1956.[15] Another Bengali surgeon Dr. A. K. Basu performed an aortic valvotomy using surface hypothermia and inflow occlusion technique in Presidency General Hospital, Calcutta (Kolkata), India in 1959.[16] So the use of various innovative techniques of pre-CPB era was not limited to USA alone.

The role of hypothermia as the sole method for open-heart surgery was an extremely short-lived one, only between 1952 and 1954, before cardiopulmonary bypass became operational. Just a handful of surgeons had the daring, technical skill, and speed to perform the task with the short, 6- to 10-minute time allowed for an intracardiac operation. With the invention of heart-lung machine, hypothermia as the soul technique of cardiac surgery was abandoned and became an adjunct in the form of the heat exchanger continues as an essential part of modern bypass-systems. Furthermore, the introduction of 'cold-cardioplegia' in 1959–1960 really started the development of ever more sophisticated and time-consuming techniques.[17]

Another interesting method of intracardiac repairs during the pre-CPB era was the controlled cross circulation method (Fig. 2). On 26th March 1954, C. W. Lillehei successfully closed a ventricular septal defect under controlled cross circulation method. In this method, a donor, usually one of the parents, was used to take up the role currently played by the heart lung machine and the oxygenator.[18]

An arterial cannula was inserted to a femoral artery of the donor and connected via a plastic tube to the ascending aorta of the child being operated. Thus the arterial supply from the donor femoral artery would support the systemic circulation of the child, when the child's heart is arrested to allow surgical correction. The systemic venous return would be sent back from the right atrium or superior and inferior vena cava to the ipsilateral femoral vein of the donor via another plastic tube and cannula. Hence the circulatory systems of both the donor and the child under operation are maintained, while the donor's femoral vessels act as a living modern day heart lung machine and oxygenator system. Lillehei also contributed to develop valve prosthesis, pacemaker of heart and trained many surgeons worldwide.

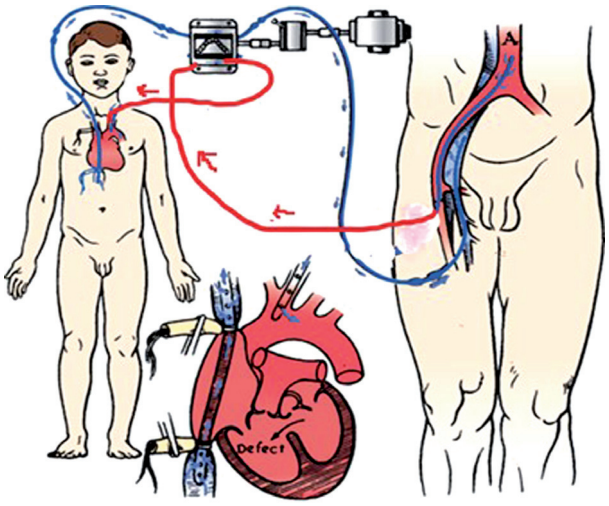

Fig. 2 – Controlled cross circulation method for intracardiac repairs.

Behind the iron curtain

During the cold war era, a significant progress was made by the surgeons of the USSR. The information on their advancement not available then became available later on. Vasilii Kolesov, a Russian surgeon, was given the rank of Major in the medical corps of the Soviet Army. During the historic siege of Leningrad, Kolesov performed many surgeries of combat injuries. Kolesov left the military service in 1953 with the rank of Colonel and became the chairman of the Department of Surgery at the First Leningrad Medical Institute and innovated various thoracic and cardiac surgical procedures. On the 25th February 1964, Kolesov performed arguably the first successful clinical coronary artery bypass operation.[19]

Another Soviet surgeon Vladimir P. Demikhov stunned the world with his magical transplant works. His kin interest in mammalian circulatory system drew him to various experiments in his early adult life. At the age of 21 in 1937, he created and implanted the first artificial heart into a dog, which survived for two hours after surgery. After serving in the Chinese-Japanese front during WW II, he returned home with several medals at the end of the war and resumed his research works. He was the master of organ transplantation in animals during the pre-CPB era. In 1951, Demikhov performed an isolated orthotopic heart transplantation in a dog. Gradually survival time of these transplanted animals increased from a few hours to several weeks. Some amazing photographs and cine of Demikhov's animal experimental works still astonishes the surgeons today.

Nikolai Amosov was a famous Ukrainian surgeon of Russian origin who made significant contribution in the development of cardiac surgery in the USSR. He studied engineering for a year before moving to medical school. This engineering knowledge helped him to innovate various devices used in cardiac surgery in the pre-CPB era.[20] He was also a notable author. His novel 'The thoughts and the heart' is an exciting novel and all cardiac surgeons must read it. Millions of copies of this book have been sold worldwide and translated into various languages (Fig. 3). A photograph of the cover of the book translated in Bengali from corresponding author's collection is portrayed here (Fig. 3).

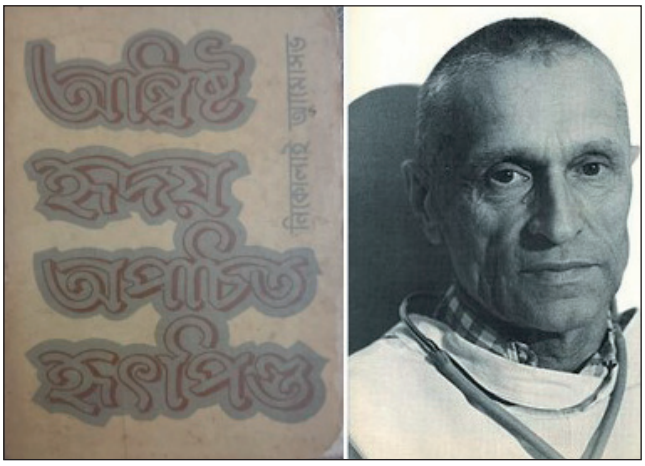

Fig. 3 – The interesting book of Nikolai Amosov translated in Bengali and Nikolai Amosov.

Early valvular operations

At the beginning of the 20th century, rheumatic fever was almost an epidemic with endocarditis and frequent mitral valvular complication. Consequently, the search for a surgical solution led to the experimental work of Alexis Carrel and Tuffier in 1914, Elliot C. Cuttler in 1923 and Sir Henry Souttar in 1925. As early as 1902, the British cardiologist Sir Lauder Brunton published an article in the Lancet with the unmistakable title 'Surgical operation for mitral stenosis'. Brunton's suggestion provoked an immediate protest by one of the leading, more conservative professors who wrote: "It is possible to do many things that are useless and some that are harmful." Carrel and Tuffier, in 1914, published an important paper in the 'Presse Medicale' entitled, 'Chirurgie des orifices du coeur' (Surgery of the orifices of the heart) and stated that "their experimentation had shown that mitral stenosis as well as certain cases of aortic and pulmonary stenosis under certain well specified conditions might benefit from surgical intervention." It had taken another 10 years before the clinical one-time successes of Cuttler and Souttar was achieved. Elliot Cuttler and his cardiologist Samuel Levine, at the Peter Bent Brigham Hospital in Boston, became successful with one transventricular mitral valvulotomy on 2nd June 1923. They had to abandon further progression as six subsequent attempts led to postoperative deaths from massive mitral regurgitation.[21]

Twenty-five years later, Charles P. Bailey and Dwight E. Harken started a new era! Bailey's first successful 'commissurotomy' on the 10th June 1948 and almost simultaneously Harken's 'valvuloplasty' on the 16th June 1948 have remained as amazing medical stories till date. In those days, their stubborn tenacity was inevitable on the face of distressing failure and harsh criticism by their peers. It is an interesting question whether, under today's ethical standards, Bailey and Harken could have gone through those painful failures. However, once the technique as well as the indications and the postoperative care methods were established, thousands of patients were relieved of the misery of severe mitral stenosis. Baily and Harken belonged to the small group of leading thoracic as well as tubercular surgeons, the latter field certainly keeping them busy enough without shouldering the frightful burden of blind cardiac surgery.[22,23] In 1951, the spring meeting of the AATS in Atlantic City was presided over by Alfred Blalock. Blalock presented his brilliant overviews on "Problems in Cardiac Surgery", stating among other topics that mitral commissurotomy was a safe and efficient operation, referring to the little-known pioneer Horace Smithy. Dr. Smithy performed his first successful closed mitral partial valvotomy on the 30th January 1948 and himself died prematurely of aortic stenosis. Russel Brock and his pulmonary valvotomy were also positively mentioned. After presidential address, all the pioneers took part in discussion. Henry K. Beecher spoke on anesthesia, Overholt on pericardiectomy. Arthur Vineberg talked about what later became the Vineberg operation.

Charles Dubost of France had become the leading continental cardiac surgeon ever since Blalock's visit to the Broussais Hospital in 1947. In addition to his contribution in the improvement of mitral surgery, Dubost performed the world's first resection of an abdominal aortic aneurysm in 1950. He was an inspiring leader, teacher, and surgeon. He made mitral commissurotomy a much easier and efficient operation in 1951 (or 1952) by developing a technique with a mechanically expandable dilator. Before that, it was done by introducing a finger guided Bailey-guillotine, a Dogliotti fingertip knife or any other sharp instrument; there was always the risk of tearing the auricular appendage or some other structures of the heart. The Dubost dilator still introduced blindly, following the exploring index, fitted snugly into the auricular tourniquet-loop and was extremely safe provided that the instrument was carefully guided into the mitral orifice. Dubost was probably the first to use such an instrument blindly through the auricular appendage, although the instrument is called the tubbs-dilator these days. The British surgeon Oswald Tubbs observed Andrew Logan use the instrument bimanually for valvular dilatation by way of the left ventricle controlling the movement through the auricular appendage. Tubbs then only had a calibrating device added by the 'Genito Urinary Instrument Company' who, from then on commercialized the instrument as the 'Tubbs-dilator'. Since 1950, Baily had used, not very successfully, a bulky curved prototype of an expandable umbrella type dilator for aortic valve stenosis. His team called the frightful instrument the 'Cadillac'. So, in fact, the Bailey aortic dilatator became the Logan, before the Tubbs and finally the Dubost mitral-dilatator.[24]

British surgeon Russel Claude Brock's contribution to mitral surgery, often forgotten, is another interesting story. With his pulmonic valvulo-infundibulectomy, as well as his mostly successful mitral commissurotomies, he should be certainly placed at the same level, if not above, the two American pioneers in the epochal breakthrough of blind cardiac surgery. According to Brock: "The great problem was to secure suitable patients." From 1946 onwards, he approached about a dozen of cardiologists and finally in September 1948, was allowed to operate on a young 22-year-old girl. All went satisfactorily and he achieved a finger separation of the fused cusps by way of the left atrial appendage. So, if the cardiologist would have agreed with an early operation, Brock might have succeeded one year before Bailey and Harken. At

the 1949 meeting of the American College of Surgeons, Brock attended the famous papers on successful commissurotomies by Bailey, Glover, and O'Neill and mentioned his own English cases successfully operated at London. As a visiting professor following the meeting in Chicago, Brock performed two mitral valvotomies with Dr. Blalock at the John Hopkins Hospital, where no such cases had been operated before 1949.[24]

Surgery for other congenital heart diseases

Surgery for coarctation of aorta and patent ductus arteriosus is possible without intracardiac intervention. The first implantation of a prosthetic valve in aorta was performed by an American surgeon Charles Hufnagel in 1952.[7,13] As mitral surgeries, surgery of congenital heart diseases was also moving forward at that time. Dr. Robert E. Gross was the first surgeon to successfully close a patent ductus arteriosus on a seven-year-old girl named Lorraine Sweeney at Children's Hospital Boston in 1938. In 1944, the first successful surgery of coarctation of aorta was performed by Dr. Clarence Crafoord in Stockholm, Sweden and 12 days later he did the second. Robert Gross was interested in coarctation surgery. Unfortunately, his first patient died, but the second patient survived. Some patients, however, needed a graft to bridge the long defect and again Robert Gross and his associates repaired the defect with insertion of a homograft aorta.[25]

Shunt operations

On the 29th November 1944, Alfred Blalock (Fig. 4) with cardiologists Helen Taussig and Vivien Thomas at John Hopkins University Hospital had performed the first successful surgery of great vessels around the heart to relieve the symptoms of tetralogy of Fallot (palliative surgery) of a one-year-old girl.[7,13] The left subclavian artery was anastomosed end to side with the left pulmonary artery thereby diverting a part of the systemic circulation towards the pulmonary circulation. This procedure known as the Blalock-Taussig shunt remained an important palliative procedure before more definitive intracardiac repair technique for tetralogy of Fallot was invented and, where intracardiac correction is not possible due to logistic reasons or inexperience of the surgical team. Shortly thereafter, Willis Potts of Chicago performed a shunt between descending thoracic aorta and left pulmonary artery without sacrificing the subclavian artery. Another type of systemic-pulmonary shunt (posterior aortic-to-right pulmonary artery anastomosis) was developed independently by David Waterson of London and by Denton Cooley of Houston. In 1958, William W. L. Glenn of Yale University performed a superior vena cava-to-right pulmonary artery anastomosis. Initially it was done on patients with a variety of congenital cardiac lesions with inadequate pulmonary blood flow, with time it used in infants requiring right heart bypass: the Fontan operation. Today it is used as bidirectional Glenn, as the first stage of a modified Fontan.[25]

Fig. 4 – Alfred Blalock. Printed with permission from credit © Yousuf Karsh.

Successful surgical treatment of pulmonary valvular and infundibular stenosis is associated with the name of Russel Brock. According to Harken, the idea of 'pulmonary valvulotomy' was put forward by Laurence O'Shaughnessy in the unfinished text of his prepared Hunterian Lecture. In fact, the suggestion may be traced back to Carrel and Tuffier. O'Shaughnessy, a promising British surgeon, was never able to deliver that lecture as he died of tension pneumothorax at Dunkirk during the evacuation of the British Army. Furthermore, another British surgeon, Holmes Thomas Sellors, performed the first pulmonary valvotomy on the 4th December 1947.[26] Having failed three times in 1947, when he was still experimented with a cardioscope, Brock eventually performed his first operation on the 2nd February 1948.[27] In the following years, Brock developed his direct approach on selected cases on tetralogy of Fallot, a strategy he preferred to the admittedly more palliative Blalock anastomosis. Brock operated hundreds of cases by this method of combined pulmonary valvotomy and infundibular resection known as the Brock procedure. For the valvotomy, Brock used a mechanical dilator, while for the infundibular canal he used a special rongeur-type instrument. His mortality was considerably lower than the one observed for the Blalock operation (probably a question of case selection).[28] The Brock procedure did not have time to gain generalized popularity before Lillehei and Kirklin, in 1955, carried out a total correction of tetralogy (intracardiac repair) under direct vision, a mere five years after Brock's first blind infundibulectomy.

In 1948, Blalock and Hanlon at John Hopkins university performed atrial septostomy for patients with transposition of great arteries to allow mixing systemic and pulmonary venous blood and were the only palliative operations for that condition until they were superseded by balloon atrial septostomy in 1966. Muller and Dammann did pulmonary artery banding to reduce pulmonary blood flow in case of ventricular septal defect in 1952.[29]

Intracardiac corrections before the CPB era

The first successful surgical repair of atrial septal defect on the 2nd September 1952 by C. W. Lillehei and F. John

Lewis in University of Minnesota. That historic operation using hypothermia and inflow occlusion of both the vena-cava and was led by F. John Lewis, longtime friend and colleague of C W Lillehei.[6] On the 26th March 1954, C W Lillehei successfully closed a ventricular septal defect under controlled cross circulation. In this technique, a donor, usually one of the parents, had his or her femoral artery connected to the aorta of the child being operated providing the supply of oxygenated systemic blood flow, while the heart is being operated. The systemic venous return of the child was delivered back to the ipsilateral femoral vein of the donor this completing the circulatory circuit. Lillehei led the team successfully, but the patient, 13-month-old Gregory Glidden, died 11 days later of suspected pneumonia. Lillehei and his team continued to use cross circulation for a total of 44 open heart operations in the following year, of which 32 patients survived. These operations included the first repair of the atrioventricular canal and tetralogy of Fallot. Cross-circulation was never widely practiced because it was too risky for the anesthetized donor. There was a joke that this operation potentially had a 200% mortality. On the 16th of March 1955, Dr. Lillehei and Dr. Varco successfully repaired the traumatic ventricular septal defects of 13-year-old Calvin Richmond. This was the first-time heart surgery to be successfully performed with the support of an animal lung for extracorporeal oxygenation. Dr. Lillehei continued to seek a better method, and in 1955, he and Dr Richard A. Dewall introduced the first clinically successful bubble oxygenator, which remained the device of choice through the 1970s.[7]

Gibbon and his machine

Another milestone in cardiac surgery was the invention of heart-lung bypass machine by John H. Gibbon Jr, a war veteran from the WW II. In 1942, he was sent on active duty to New Caledonia in South Pacific. Later he served as a surgeon in the Burma-China-India theater, achieving the rank of Lieutenant Colonel. After the war, on the 6 May 1953, he performed the first successful open heart procedure, on an 18-year-old girl named Cecilia Bavolek using total cardiopulmonary bypass. This was the beginning of modern cardiac surgery.[30]

We now turn to the zenith of the mid-century revolution. After the first successful surgical intervention on heart (atrial septal defect closure) in 1952, by a series of unsuccessful attempts forced John H. Gibbon to give up any further trials in 1953. The advent of modern open-heart surgery began in the spring and summer of 1955 when the two unforgettable pioneers John W. Kirklin at the Mayo Clinic and C. W. Lillehei at the University of Minnesota, initiated the routine use of cardiopulmonary bypass for open heart surgery.

Conclusion

The development of cardiac surgery is an interesting chapter of medical history. Once considered taboo even to touch, the heart has become an organ with so many successful operative procedures invented by the cardiac surgeons. The innovative moves adopted by the surgeons to perform operations before the development of cardiopulmonary bypass were amazing. The fascinating journey by these pre-CPB era pioneers made significant contribution in the development of the modern day cardiac surgery.

Conflict of interest

There are no conflicts of interest nor any disclosures to be made by any author.

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