The main epochs and timeline of cardiac and great vessel surgery

a) 1797-1896: incubation period with animal experiments and human casuistics: 1798:
Use of 7°C cold sea water bath for the curing of fever, convulsions and insanity (J. Currie) 1
1797: M. Baillie described the transposition of the great vessels (TGA) of the heart
1801?: First pericardiostomy (drainage after an incision) for pericardial effusion described
by Francisco Romero 2
1810: Pericardial drainage for tamponade of a stab wound (D. Larrey). The patient
survived for less than a month, but another drainage carried out by Larrey in 1824 led
to a better outcome
1812/13: C. J. La Gallois outlined the possibility of maintaining life with the help of an
artificial pump replacing the heart 3
1849: Isolated renal perfusion with defibrinated blood (C. E. Loebell) 4
1869: First attempts for the artificial oxygenation of blood (C. Ludwig, A. Schmidt) 5
1872: First experiments with the valvotomy of the aortic valve (O. Becker, E. Klebs) 6
1873: Removal of a foreign body from the heart by G. W. Callender
1882: W. von Schröder designed an oxygenator for perfusion of isolated organs 7
Visionary concept of an artificial heart in the novelette The Vivisector Vivisected by
Ronald Ross 8
1885: First artificial heart-lung machine, a film oxygenator („Respirations-Apparat für isolierte
Organe“) constructed by M. v. Frey and M. Gruber 9
1886-97: Successful side-to-side (P. Postemski) 10 and end-to-end suture of an artery with
invagination technique in man (J. B. Murphy, E. Payr) 11
1888: Endoaneurysmorrhaphy instead of the dangerous ligature of aneurysms (R. Matas) 12
1890-1915: Prototypes of venous bubble oxygenators designed by C. Jacobi 13
1893: First successful suture of the pericardium during an operation (H. C. Dalton 14,
D. H. Williams 15)
64:870, 3 C. J. La Gallois: Expérience sur le principe de la vie. Paris, 1812, 4 Diss. Marburgi
London, John Murray, 1923, 9 M. von Frey, M. Gruber: Arch. Physiol. 1885; 9:519, 10 P.
Williams: Medical Record 1897; 51:439

b) 1896-1937: preparatory phase of heart surgery and great vessels: closed interventions:
1896: First successful suture of a punctured heart wound (L. Rehn)
1897: Proposal of the sternum-splitting incision for access to the chest (H. Milton, Cairo)
1898: Brentano, D. W. Samways and B. C. Cantab propose the dilatation of the stenotic
mitral valve2
E. Delorme proposes the release of the armoured heart with pericardectomy
1899: Cervical sympathectomy proposed for relief of pain in angina pectoris (C. A. François-
Franck)
1902: Technique of the end-to-end anastomosis of great vessels (A. Carrel) 3
Ligature of an aneurysm of aorta (T. Tuffier) 4
1903: Indications for operative relief of pericarditis constrictiva (cardiolyis; L. Brauer) 5
1906: Transplantation of frozen conserved vessels (A. Carrel) 6
1903-10: Pulsatile blood flow leads to a greater degree of hemolysis (Hoffmann, Hooker) 7
1907: Unsuccessful embolectomy from the main pulmonary artery (F. Trendelenburg) 8
John Munro conceives the possibility of ligation of the patent (open) ductus arteriosus Botalli through a median sternotomy 9
1907: F. Sauerbruch's suggestion of compression of the superior and inferior vena cava to control cardiac hemorrhage 10
1908: H. Cushing's animal experiments on reconstruction of valvular lesions 11
1910: First successful pericardiectomy (M. P. Hallopeau) 12
1903-15: Bubble oxygenator (T. G. Brodie, D. R. Hooker) 7
1907: F. Sauerbruch's suggestion of compression of the superior and inferior vena cava to control cardiac hemorrhage 10
1912: First successful porto-caval anastomosis with the aid of an Ecks' fistula (P. Rosenstein) 13
1913: Partial pericardiectomy is sufficient for the release from constrictive pericarditis (F. Sauerbruch) 12
First unsuccessful (E. Doyen) and successful stretching (M. Th. Tuffier) of an aortic stenosis with digital invagination of ascending aorta 14
1915: Rotating disk film oxygenator (D. R. Hooker, A. N. Richards and C. K. Drinker) 14
1916: Removal of the cervical sympathetic chain and the first dorsal ganglia bilaterally for denervation of the heart in angina pectoris (T. Jonnesco) 15
1923: Successful repair of a traumatic transection of the thoracic aorta (Dshanelidze) 16
1924: Successful embolectomy from the main pulmonary artery (L. Kirschner) 17
1925: First successful transauricular digital sprinkling of the mitral valve (H. Souttar) 18
1926/27: Invention of the valveless roller pump for perfusion of isolated organs (B. Issekutz) 19
1928: Restoration of contractility in isolated muscles by perfusing their arteries with oxygenated blood (J. Kay) 20
Refrined type of rotating disk film oxygenator (L. E. Bayliss et al.) 21
1929: Heart catheterism with the help of a ureter catheter designed for resuscitation instead of the transthoracic heart punction (W. Forssmann) 22
1930: Artificial heart for cat experiments (Gibbs) 23
1931: Successful resection of an aneurysm of the right ventricle (F. Sauerbruch) 24
1932: Albert S. Hyman invents an artificial pacemaker to resuscitate patients 25
1933-37: W. B. Kouwenhoven and O. R. Langworthy, C. J. Wiggers discover in animal experiments that countershock can restore a fibrillating heart to normal rhythm 26
1937: First successful application of Wigger's countershock for terminating intraoperative ventricular fibrillation (C. S. Beck) 27
1926-34: Construction of a steady flow roller pump for transfusion (Clemens, Beck, M. E. DeBakey) 28
1935/36: Abrasion of epicard in order to augment the blood flow through hyperemia and revascularization of myocardium by a pectoralis muscle graft (C. S. Beck) or with a cardio-omentopexy (L. O'Shaughnessy) 29
1934-37: Extracorporeal blood circulation unit with oxygenator for complete heart-lung bypass for 30-40 minutes in animals (J. H. Gibbon) 30
1937: First (unsuccessful) attempt to close a patent ductus arteriosus (J. W. Strieder) 31


c) From 1938: pioneer phase of the cardiac and great vessel surgery: closed (blind) heart interventions and open cardiac operations under direct vision without or by means of (deep) hypothermia or crossed circulation:

1938: First successful ligature of an uninfected Botalllo's duct (R. E. Gross, J. P. Hubbard) 1 Cardio-omentopexy for coronary ischemia (L. O'Shaughnessy)
1938: Cardiopneumopexy after removal of the overlaying pericardium for increasing the coronary blood flow (A. Lezius). This procedure was revived in 1958 by Smith in Seattle
1939: First successful ligature of an infected Botalllo's duct (O. Tubbs). Further 9 cases were reported in 1944 (and 6 of these remained cured by chemotherapy)
1941: Right-heart catheterization became a routine procedure (A. Courand, H. A. Ranges) 2
1944: Successful resection of the aortic coarctation by cross-clamping the aorta and direct suture in 2 patients (C. Crafoord, K. G. V. Nylin) 3
1945: Experimental resection of a short segment of the aorta with re-anastomosing (R. Gross, Ch. Hufnagel) 4
1944: Artificial Botalllo's duct for amelioration of hypoxemia and cyanosis and in order to increase the pulmonary artery pressure gradient in pulmonary stenosis by means of an anastomosis between left subclavian and pulmonary artery (Blalock-Taussig anastomosis) 5
1946: Potts operation: a direct side-to-side anastomosis between the descending aorta and the pulmonary artery in small infants (W. J. Potts et al.) 6
1946: Removal of 134 missiles and other foreign bodies from the chambers of the heart and great vessels with no death (D. E. Harken, P. Zoll et al.) 7
Tunneling of the internal mammary artery through the myocardium (A. M. Vineberg) 8
1947/48: First saphenous bypass for bridging an obliterated artery 9
Subclavian artery technique in a patient with coarctation (O. T. Clagett) 10
First successful pulmonary valvotomy (H. Sellors) 11, also by the use of a cardioscope fitted with a retractable knife (R. C. Brock) 12
Closed closure of atrial septal defects by invagination of the right atrial wall and performing a patch by mattress suture (R. Cohn, G. Murray) 13
1948/52: Brain perfusion in dogs with artificial oxygenated blood (V. O. Björk) 14
Transatrial commissurotomy (valvulotomy) with a mitral valve knife (C. P. Bailey et al) 15 and valvuloplasty (D. E. Harken, L. B. Ellis et al.) 16
First use of an arterial homograft (R. Gross)
1949: Modified film oxygenator consisting of multiple rotating spiral coils combined with a Dale-Schuster pump was able to support the circulation and respiration of dogs for up to four hours (J. Jongbloed) 17
1949/50: Decrease of body's oxygen requirement with the grade of hypothermia in linear fashion, when shivering and heightened muscle tone had been previously eliminated. Proposal of deep hypothermia for elective cardiac arrest and open cardiac procedures with the help of „inflow occlusion“ (W. G. Bigelow et al) 18
1950: A successful closure of an atrial septal defect in a small child under elective cardiac arrest for 5 minutes (Budapest, II. Pediatric Clinic), only six months after
Bigelow’s first publication 19
Homoplastic transplantation of the heart and lungs in warm-blooded animals (dogs; V. P. Demikhov) 20
1951: Successful digital splitting (instead of a finger knife)* of a mitral stenosis (Á. Eisert and T. Sarvay) 23
1951: Use of an arterial homograft in the repair of an abdominal aortic aneurysm (C. Dubost et al.) 24
Man-made graft, a caged plastic ball device is well-tolerated in the bloodstream (C. A. Hufnagel) 25
Initiation of modern carotid surgery by end-to-end anastomosis between external and internal carotid (M. Fischer, R. M. E. Carrea et al.) 26
1950/54: „Parabiosis“ with the aid of a human donor as a biologic oxygenator 27. After successful experiments in animals it was recommended for open cardiac operations (H. E. Warden, M. Cohen et al., C. W. Lillehei et al.) 28
1952: Transventricular dilatation of the aortic stenosis using a three-bladed dilator (C. P. Bailey, H. P. R. Ramirez) 29
1952: Closure of an atrial septal defect with atrio-septopexy (C. P. Bailey et al., R. E. Gross et al.) 30
1952: Paul M. Zoll develops the first successful cardiac pacemaker 31
1952: Closure of atrial septal defect with the aid of hypothermia and inflow occlusion in one case (J. F. Lewis, M. Taufic) 32 in Swan’s ice bed (surface cooling) 33
1950-54: Correction of Tetralogy of Fallot without heart-lung machine by means of controlled cross circulation (O. H. Wangensteen, C. W. Lillehei; et al.) 34
1953: First successful carotid endarterectomy (M. DeBakey) 35
1953: Successful surgical correction of aortic regurgitation (C. A. Hufnagel, W. P. Harvey) 36
1954: Transatrial dilatation of mitral valve (Ch. Dubost)
1954-62: Modern treatment of dissecting aortic aneurysm is initiated by M. E. DeBakey et al., F. C. Spencer and H. Blake 38
1955: First closure of a ventricle septal defect using the heart-lung machine (J. W. Kirklin) 39
1957: „Isthmusplastic“ operation for aortic coarctation by means of a homograft or a Dacron patch (K. Vosschulte) 40
1958: Replacement of the heart in an animal with a mechanical device (T. Akutsu and W. J. Kolff) 41
1958: Totally implanted pulse generator for pacing the heart in Adams-Stokes syndrome (A. Senning, R. Elmqvist) 42
1965: Total correction of the Tetralogy of Fallot in small children using cardiopulmonary by-pass and deep hypothermia (L. K. R. McMillan et al.) 43
1966: Balloon atrial septostomy as a palliative approach in complete transposition of the great arteries without thoracotomy (W. J. Rashkind, W. W. Miller) 44


4) Since 1953: era of the open heart and great vessel surgery with the aid of extracorporeal bypass: valvular surgery under direct vision and coronary bypass operations:

1953: Successful closure of an atrial septal defect using a heart-lung machine (J. Gibbon) 1
1956: Resection of a fusiform aneurysm of the entire ascending aorta using cardiopulmonary bypass (D. A. Cooley, M. E. De Bakey) 2
1956: Repair of a pure mitral insufficiency by suture plication of the valve commissures under direct vision (annuloplasty; C. W. Lillehei et al.) 3
1958: Bypassing the right side of the heart using a shunt between the superior vena cava and the right pulmonary artery (W. W. L. Glenn) 4
1961-68: Mechanical ball-valve prosthesis for mitral and aortic valve replacement (A. Starr, M. L. Edwards) 6
1961: Free-floating disk for valve replacement (Björk-Shiley valve)
Outline of the concept of arterial counterpulsation for assisted circulation (R. H. Clauss, W. C. Birtwell et al.) 7
1961: External direct current shock immediately after the R wave is able to avoid the vulnerable phase (method of the synchronized cardioversion, B. Lown et al.) 8
1962/1967: Aortic valve replacement with cadaver valves or using the patient's own pulmonary valve (D. N. Ross) 10
1962/67: Autogenous saphenous vein as a coronary artery bypass graft (CABG; D. C. Sabiston Jr, R. Favaloro) 11
1963: Left ventricular assist device, a bypass pump used in a human: the first implanted artificial heart 12
1964: Internal mammary artery-coronary artery anastomosis for coronary revascularization V. I. Kolesov) 13, from 1967 with the help of mechanical suturing and the heart-lung machine in
standby position

1964: Homograft aortic valve replacement in aortic incompetence and stenosis (B. G. Barratt-Boyes)

1967: Mitral valvulopathy with the use of aortic heterografts (experimental and one clinical case; A. Carpentier, J. C. Chanard, P. Laurens et al.)

1967: First human heart transplantation (Chr. Barnard)

1969: Pig's aortic valve for replacement (K. A. Kaiser et al.)

1970/71: Isolation of the cyclosporin from the fungus Tolypocladium inflatum and discovery of its immunosuppressive effect (J. F. Borel, Z. L. Kis)

1971: Prosthetic ring annuloplasty (A. Carpentier)

1978/83: Cyclosporin is approved for clinical use to prevent graft rejection after organ transplantation (R. Y. Calne et al).

1980: Chordoplasty (A. Carpentier)

1982: W. C. De Vries attempts a permanent replacement of the heart with a mechanical prosthesis, and shortly after with a Jarvik pump in another cardiac cripple

1985: First implantable cardioverter defibrillator (AICD; M. Minkowski, M. M. Mower et al.)

1989: World Congress on Heart Valve Replacement states: the Starr-Edwards valve still remains the gold standard (J. S. Swanson, A. Starr, G. G. Siposs)


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e) Coronary surgery on beating heart without extracorporeal bypass:

1994-96: G. Ribakove introduces the revolutionary 'port-access' procedure, a clinically applicable less invasive system for cardiac surgery

1996: First less invasive mitral valve repair via small left anterior small thoracotomy or small sternotomy (MIDCAB) instead of full sternotomy (St. B. Colvin,
Mid 1990's: By developing myocardial wall stabilizers cardiac surgeons reintroduced less invasive surgical techniques in beating heart for aortic valve replacement, mitral and tricuspid valve repair, congenital heart defect surgery and multi-vessel coronary artery bypass grafting (CABG) without using extracorporeal bypass.

Late 1990's: Robotics appear as experimental procedures even in the cardiac surgery.


Coronary bypass grafting on beating heart with stabilization of the myocard (Shennib, Lee and Akin 1997, Kappert, Cichon, Schneider et al. 2001)

2002: Resection of the mitral valve by means of robot surgery (Deutsches Herzzentrum, München)


2006: Autologous bone marrow-derived stem-cell transfer in myocardial infarction

Transplantation of a beating conserved heart (R. Körfer, Bad Oeynhausen)

Ongoing tendency in the cardiac surgery: stem-cell therapy, tissue engineering, minimal invasive access for the aortic valve replacement, restitution of the tendon cords at mitral valve prolapse, endoscopic graft harvesty, robot surgery, e.g. TECAB (total endoscopic coronary artery bypass), intra-uterine heart surgery and endoscopic placed aortic prosthesis

Literature

6 In a double-blind, randomised controlled trial in 67 patients the intracoronary stem-cell transfer was associated with a significant reduction in myocardial infarct size and a better recovery of regional systolic function (University of Leuven: S. Janssens, Chr. Dubois, J. Bogaert et al.: Lancet 2006; 367:113). In Hungary the first attempt of such a stem-cell transfer was made at the Debrecen University in 2005, too (Á. Péterffy et al.).

f) Evolution of the heart-lung machine and the extracorporeal circulation (s. also table 4/a):

1915: Rotating disk oxygenator (D. R. Hooker)
1928: Modified disk oxygenator using a columns of cones that rotated within a series of stationary plates (L. E. Bayless et al)
1934: The idea of the heart-lung machine for use in humans is born (J. Gibbon)
1935: Perfusion pump by means of pulsatile gas pressure (A. Carrel and C. A. Lindbergh)
1948: Modern rotating disk oxygenator for brain perfusion (V. O. Björk)
1949: Film oxygenator with a Dale-Schuster pump for mechanically sustained circulation and respiration (J. Jongbloed)
1950: Bypassing the right side of the heart with shunting the venous blood directly into
the pulmonary artery (W. H. Sewell Jr., W. W. L. Glenn) 8
1951: First use a pump oxygenator for a partial bypass of the right heart in human (A. M. Dogliotti, A. Constantini) 9
Bypassing the left side of the heart for entry into the left heart to expose the mitral valve (G. H. A. Clowes Jr.) 10
First unsuccessful use of a heart-lung machine in humans (Cl. Dennis, Minnesota) 11
(This tragically ending case and the inability of Gibbon’s to repeat his initial atrial septal closure success in 1953 created a dampening effect on the further evolution of the heart-lung machine. At the same time the Lillehei group also realized the limitations of biologic oxygenation with the cross circulation.)
1953: Successful closing of an atrial septal defect using a heart-lung machine (J. Gibbon) 15
1955: Direct vision closure of ventricular septal defects in 8 patients using cross circulation (C. W. Lillehei et al) 16
1956: Modified rotating disk oxygenator by substituting stainless steel, Teflon-coated disks and a pyrex silicone-coated chamber (E. S. Cross et al) 17
Total cardiac bypass in humans utilizing a pump and heterologous (dog) lungs (G. S. Campbell, N W. Crisk et al.) 18
1956: Direct vision intracardiac surgery in man using a simple disposable artificial bubble oxygenator in conjunction with a vertical blood-oxygen mixing tube (to remove the large bubbles) and a DeBakey pump (C. W. Lillehei, R. A. DeWall et al) 19
Disposable membrane oxygenator (W. J. Kolff, D. B. Effler et al.) 20
1958: Disk oxygenator of E. B. Kay and F. S. Cross (PEMCO) 21
1959: Bilateral bypass without an oxygenator and with deep hypothermic circulatory arrest (C. E. Drew and I. M. Anderson) 22
1978: Coronary artery surgery with patient's lung as oxygenator (B. Glenville, D. N. Ross) 23
2000: Re-introduction of the Drew-Anderson technique in coronary artery bypass grafting (attenuates Systemic Inflammatory Response Syndrome, SIRS) 24

g) Evolution of the interventional techniques in cardiology:

1964: Relieving stenosis of peripheral arteries by means of a guidewire, catheter and then a rigid dilator (C. T. Dotter, M. P. Judkins) 1

1968: Beginning of arrhythmia surgery by interrupting the reentrant circuit through destroying the accessory Kent bundle in WPW syndrome (W. C. Sealy) 2

1974: Percutaneous transluminal angioplasty (PTA) with a balloon-tipped catheter for the dilating of peripheral arteries (A. Gruentzig, D. A. Kumpe) 3

1977: Percutaneous transluminal coronary angioplasty (PTCA; A. Gruentzig, A. Senning, W. E. Siegenthaler) 4


1980: Contrast visualization of the coronary arteries is safe in acute myocardial infarction (M. A. DeWood, J. Spores et al)

1981/82: Successful treatment of recurrent ventricular tachycardia using electrode catheter ablation technique (R. Gonzalez et al., J.J. Gallagher et al.) 7

1982: Balloon dilatation to split the commissures for relief of pulmonary valve stenosis in children (balloon valvuloplasty; J. S. Kan, R. I. White et al.) 8

1982/83: Creation of a functional atrial septal defect using a balloon catheter (W. J. Rashkind) or by attaching a surgical blade to the catheter (S. C. Park, W. H. Neches et al.) 9

1983: Percutaneously introduced 'double-disk prosthesis' for closing an atrial septal defect or a patent ductus arteriosus 10

1983: Reintroduction of intravenous infusion of a high dose of streptokinase for thrombolysis in acute myocardial infarction

'The development of clot-specific antithrombotic agents with little or no systemic lytic action and the search for an ideal thrombolytic agent are still in progress.'

1986: Coronary stent implantation 12 gains widespread acceptance after the successful reduction of early stent thrombosis by the use of thienopyridines and high pressure stent implantation 13.

2003: Drug-eluding stents achieve further decrease in restenosis 14 and target lesion revascularization, but generate great concerns about hypersensitivity reaction and late stent thrombosis 15

2003-2006: Absorbable magnesium alloy stents show in animals complete and rapid endothelisation, low intima proliferation, very small inflammatory changes and complete absorption within 2 months 16.

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11. April 1949: First experimental method for biventricular bypass with deep-core cooling using a heat exchanger (Charles E. Drew) and circulatory arrest for 30-45 minutes in three children with great atrial septal defect (ASD) in deep hypothermia to 15°C (C. E. Drew, I. A. Anderson; s. 1959)

2. September 1952: Successful closure of a VSD (ventricle septal defect) with the help of surface cooling hypothermia and inflow occlusion (F. J. Lewis)

6. May 1953: first successful open cardiac surgery using a heart-lung machine (J. Gibbon)

26. March 1954: controlled cross circulation with a living donor (parabiosis) for correction of the VSD (C. Walton Lillehei)

1954-: Successful closure of VSD with the help of disk oxygenator (J. Webster Kirklin, Mayo Clinic, Rochester)

1957: Bubble oxygenator (R. A. De Wall, C. Walton Lillehei, Minneapolis)

1959: Biventricular bypass combined with autologe lung perfusion as a biological oxygenator (C. E. Drew, I. M. Anderson)

Historically developed conditions which should have been established before performing successful intracardiac surgery:

- teamwork between surgeons and anaesthetists in each heart centre.
- intratracheal anesthesia, controlled ventilation and intensive care unit
- availability of special cardiac anaesthesia techniques
- blood bank, hemodilution, cell saver and rapid estimation of coagulation disorders
- large-scale shock treatment, resuscitative techniques and internal defibrillation (Cl. Beck, 1947) as well as external DC shock cardioversion (B. Lown, 1961)
- invasive and non-invasive haemodynamic monitoring and diagnosis (e.g. Holter monitoring, CT, MRI, heart catheterism, angiocardiography, TEE) as well as interventional cardiology procedures
- full-scale perioperative hemodynamic monitoring
- possibility of acute bypass
- IABP (intracortical balloon pump) and other assist-devices
- cardioplegia and other cardioprotective drugs
- hypothermia
- extracorporeal circulation, heart-lung machine
- xenograft, biological prosthesis and artificial valves
- donor bank, transplantation team, homograft tissue bank, tissue typifying and immunosuppression (antilymphocyte serum, glucocorticoids, monoclonal T-cell antibodies OKT-3, anti-thymus cell globuline ATG, Rapamycine, cell antibodies and cyclosporin A) in case of heart transplantation
- continuous survey on morbidity and mortality as a national and international project (EuroSCORE)
- availability of sufficient financial support for instrumentation, donor conditioning, operative procedures, intensive care beds and staff, as well as for scientific research, postgraduate training, and for rehabilitation centres

Literature:
Comroe, Julius H., Jr: Exploring the Heart. Discoveries in Heart Diseases and High Blood
Currie, James: Medical Reports on the Effects of Water, cold and warm, as a Remedy in Fever and other Diseases. Liverpool, J. M'Creery 1798

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