



SNS COLLEGE OF ALLIED HEALTH SCIENCES
SNS Kalvi Nagar, Coimbatore - 35
Affiliated to Dr MGR Medical University, Chennai



DEPARTMENT OF CARDIOPULMONARY PERFUSION CARE TECHNOLOGY

COURSE NAME : PRINCIPLES OF PERFUSION TECHNOLOGY I

2nd YEAR

TOPIC : HISTORY OF EVOLUTION OF CPB



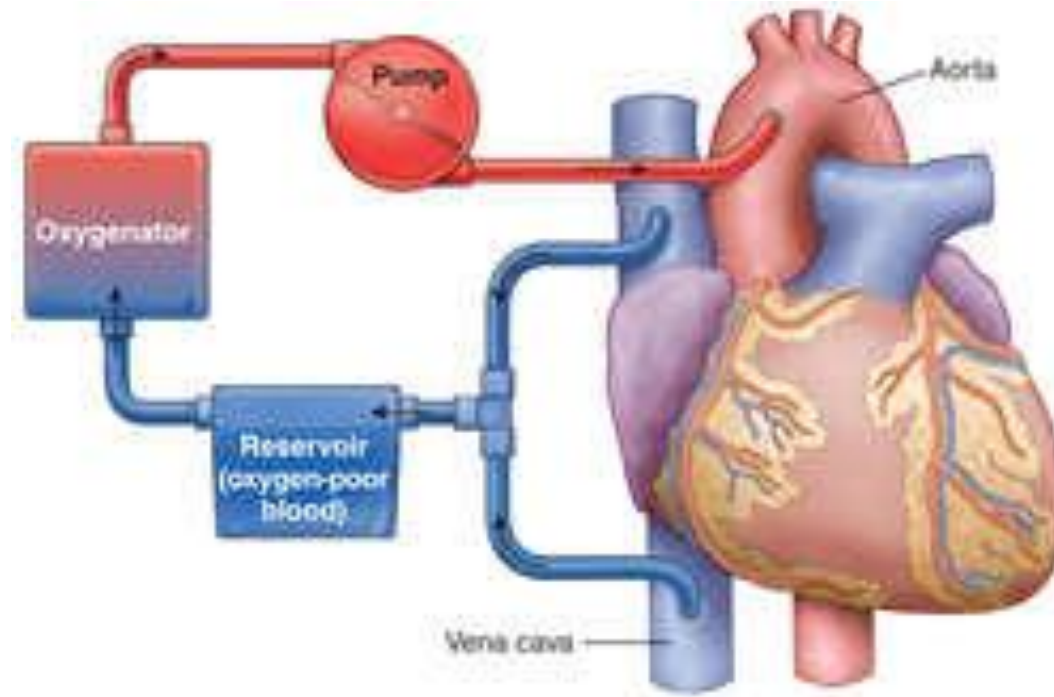
History of Evolution of CPB



CPB

Cardiopulmonary bypass is a technique that temporarily takes over the function of the heart and lungs during surgery to maintaining the circulation of blood and O₂ content of the body.

- The keystone to this astonishing progress has been CPB by extracorporeal circulation (ECC).
- These methods for ECC have allowed surgeons to empty the heart of blood, stop its beat as necessary, open any desired chamber, and safely carry out reparative procedures or even total replacement in an unhurried manner.





HISTORY OF CPB



The first operation performed using cardiopulmonary bypass and open cardiotomy was on **April 5, 1951** by **Dr. Clarence Dennis** at the University of Minnesota. This was following four years of experiments with dogs





THE OPEN HEART ERA IS BORN



- On September 2, 1952 **Dr. F. John Lewis** successfully closed a secundum atrial septal defect in a 5 year old girl under direct vision using **inflow stasis and moderate total body hypothermia**.
- **Bigelow, Boerema, Lewis and Swan** – pioneers of **Hypothermia**
- Hypothermia with inflow stasis proved to be an excellent method for simple atrial defects



Original Open-Heart Surgeries and Techniques Developed at the University of Minnesota, 1952-1957



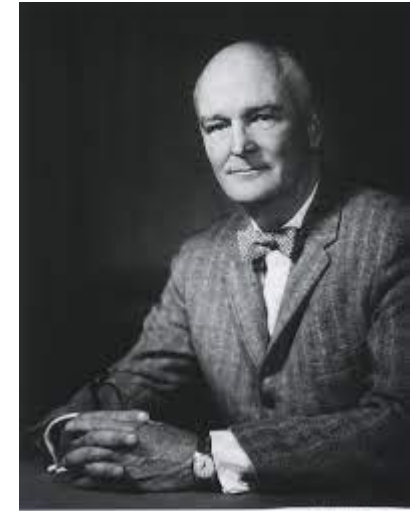
Surgery/Technique	Date	Technique
Atrial septal defect closure	September 2, 1952	General hypothermia
Ventricular septal defect closure	March 26, 1954	CPB (by cross circulation)
Atrioventricularis communis correction	August 6, 1954	Same as above
Tetralogy of Fallot intracardiac correction	August 31, 1954	Same as above
Disposable bubble oxygenator for CPB	May 13, 1955	
First use of direct cardiac stimulation by myocardial electrodes with a pacemaker for complete heart block	January 30, 1957	



JOHN GIBBON



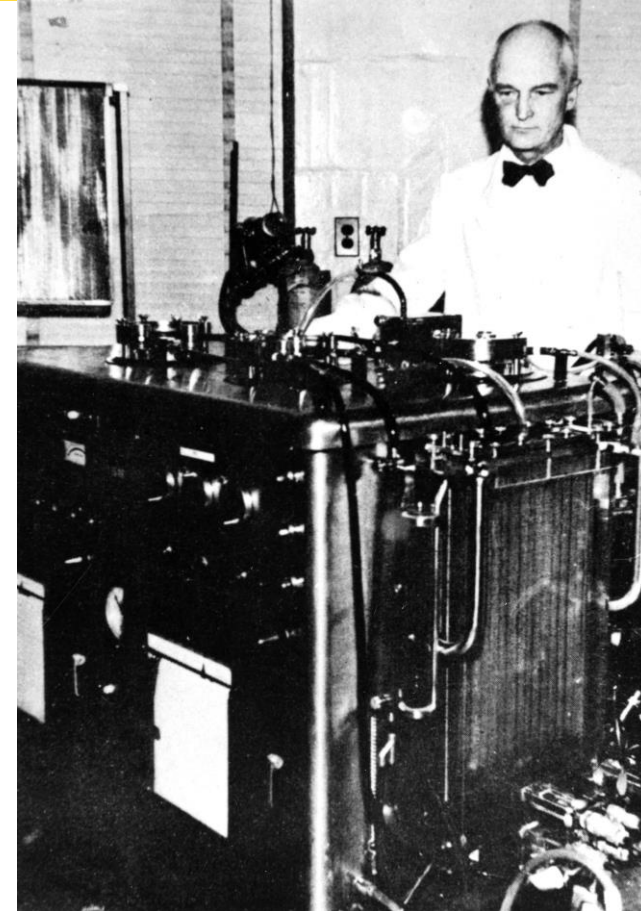
- Dr. John Gibbon developed a **heart-lung machine** that he used in 1953 to successfully complete the first open-heart operation.
- He was 1st to succeed in using total extracorporeal circulation to facilitate the cardiac surgery.
- **On May 6, 1953** Dr. Gibbon performed his first successful operation using an extracorporeal circuit on an 18-year-old woman (Cecelia Bavolek) with a large **Atrial septal defect**.



GIBBON'S CONTRIBUTION

Important contributions of Gibbon in CPB

- **Rinsing of the circuit** before CPB
- Use of **colloids for priming** solutions
- Small priming volume to **reduce hemodilution**
- Importance of measuring O₂ saturation of venous blood to assess tissue perfusion



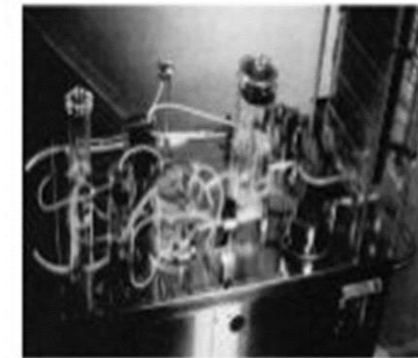


GIBBON'S CONTRIBUTION (CONT)



- Systemic pressure to be maintained at least 50 – 65 mmHg
- Perfusate and blood trapped should be salvaged and returned to patient
- His equipment included safety devices for shutting off the pump automatically in case the blood in the reservoir reached too low a level or line pressure become too high
- He experimented with pulsatile flow, incorporated a device for arterial filtration and used plastic tubing

1955: Mayo Clinic-Gibbon heart lung machine (screen oxygenator + roller pump). This model was used in first series of open heart operations performed by Dr. John Kirklin and associates at the Mayo Clinic





GIBBON'S CONTRIBUTION(CONT)



- He demonstrated successful surgical procedures in **heparinized** subjects
- He described the phenomenon of heparin rebound, noted that **protamine** could produce hypotension and advocated use of myocardial temperature probes
- He considered heparin / protamine titration test after CPB, once it become available
- He knew that amount of hemolysis was related to length of CPB
- He was aware the necessity of an assistant who could give an undivided attention of CPB, the forerunner of perfusionist today



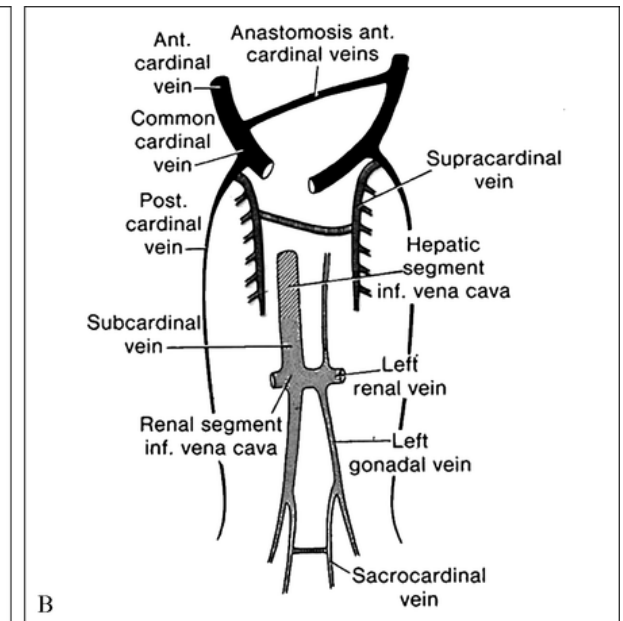
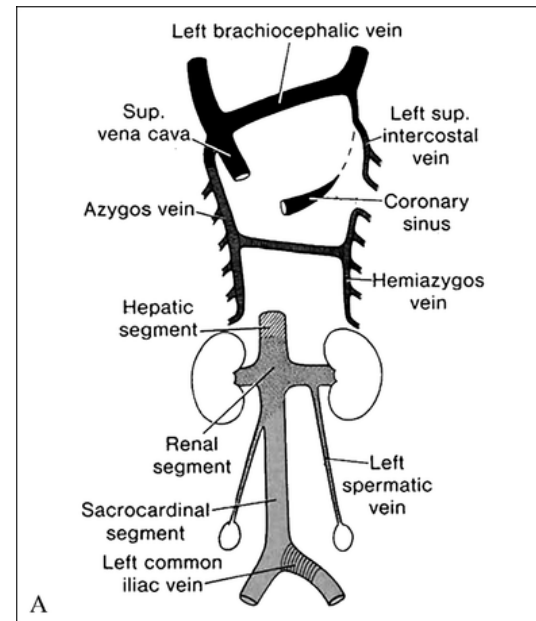
Heparin

- Heparin is the oldest anticoagulant used in clinical medicine. Paradoxically, heparin was discovered by **Jay Mclean** in **1916** in an attempt to isolate a thromboplastic agent



Azygos Flow

- Dogs uniformly **survive 30 minutes** with both venaecavae occluded and recover without discernible sequelae, if the azygos vein is open. Azygos vein flows 8 to 14 ml/kg body weight/min; normal basal or resting cardiac output = 100 to 160 ml/kg body weight/min.
- Approximately **10% of the so called basal cardiac output** was needed to sustain animals unimpaired physiologically for a reasonable period of time at normothermia.

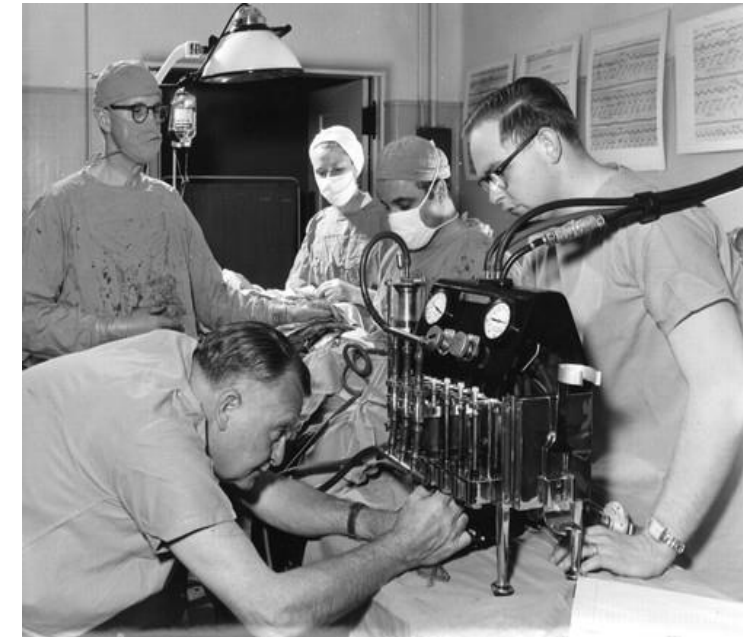




The Dodrill Experience with Autogenous Lung Pump Bypass

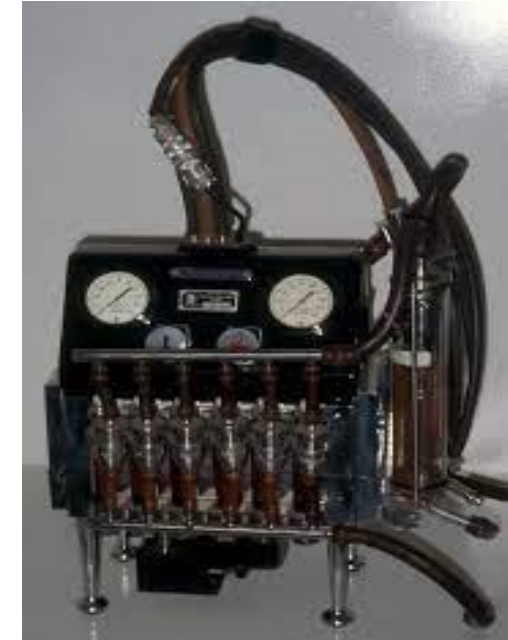


- Dodrill et al. in collaboration with the General Motors Corporation developed a blood pump for animal and clinical use as a right, left, or combined heart bypass with autogenous lung oxygenator.
- The **Dodrill–GMR heart machine**, considered by some to be the first operational mechanical heart was successfully used while performing heart surgery.



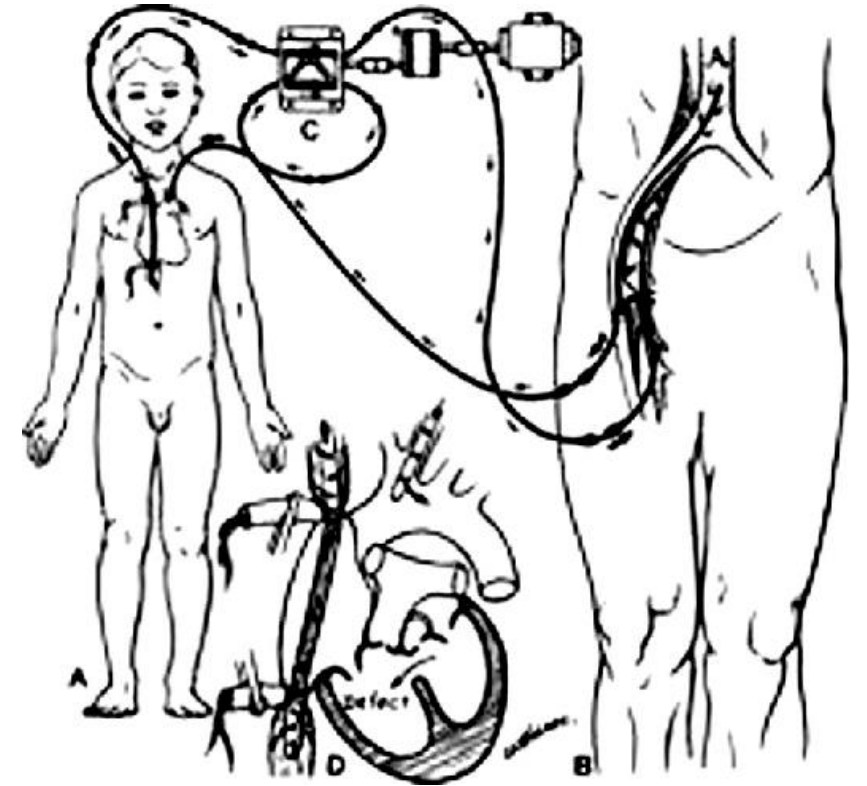
Dodrill-GMR heart machine

- In their series of four patients, three had partial heart bypasses (two left sides, one right side).
- All three lived but in only one therapeutic procedure (pulmonary valvuloplasty) carried out
- 1950s: Dodrill had the intention to bypass only the right/left heart (without oxygenation) or to use the patients own lung as an oxygenator



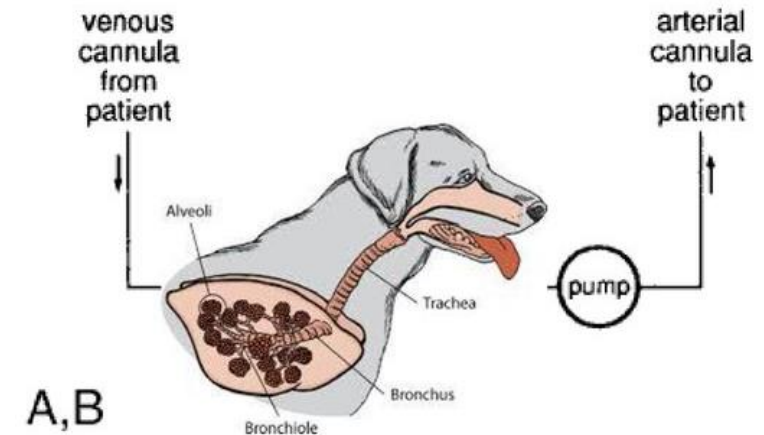
Cross Circulation

- On **March 26, 1954** **Dr. C. Walton Lillehei** - 1st surgical closure of VSD under controlled the **Cross circulation**
- The procedure dubbed cross circulation linked the two circulatory systems and provided **CPB in the child through the heart and lungs of the adult donor**



Heterologous Biologic Oxygenator

- Beginning on **March 1, 1955**, a series of clinical open-heart surgeries was started at the University of Minnesota using a pair of **canine lungs as oxygenators**
- Twelve patients were operated on, with four long-term survivors. 2 more patients were operated on, with 5 long-term survivors for a total of 14.
- The only other attempt to use heterologous lungs at that time was the report of **William. T. Mustard** using **monkey lungs**. In their series of seven patients, there were no survivors.





THE MECHANICAL PUMP OXYGENATOR FOR CARDIOPULMONARY BYPASS: BEGINNING OF AN ERA



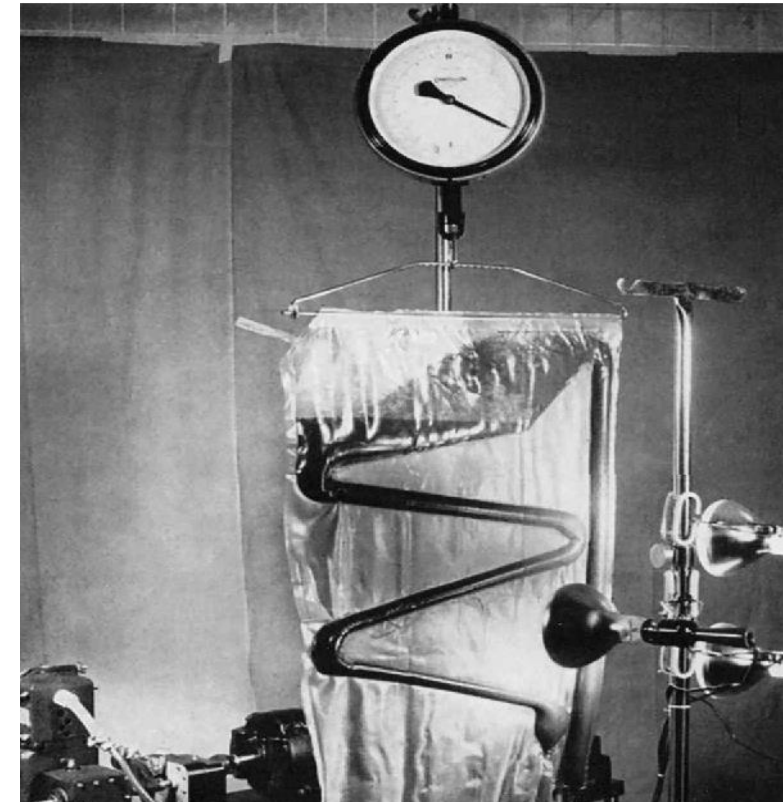
- On **March 22, 1955** first clinical application of modified design of the Gibbon-type pump oxygenator by **Jones et al. and Donald et al.**
- On **May 13, 1955, DeWall and Lillehei**, based on their dog laboratory research, began routine clinical use of a simple disposable bubble oxygenator
- It was efficient, inexpensive, heat sterilizable, easy to assemble and check, and had no moving parts. Because it could be assembled from commercially available materials at a small material cost, it was also disposable

1953:Walton Lillehei's heart-lung-machine
bubble oxygenator (DeWall oxygenator)
Sigmamotor pump disposable plastic tubing inexpensive



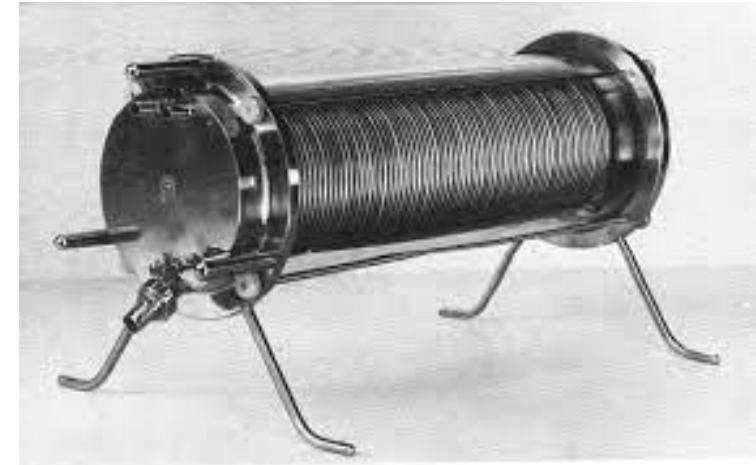
Bubble Oxygenator

- In 1966, DeWall et al. made a very significant advance in oxygenator design with the introduction of a hardshell bubble oxygenator with an integrated oxygenator and omnithermic heat exchanger in a disposable, presterilized, polycarbonate unit



Rotating Disc Film Oxygenator

- **Bjork** worked on the first disc oxygenator in 1948. Later **Dr. Frederick Cross** along with **Earl Kay** in 1956 developed a rotating disc oxygenator. This oxygenator, called the **Kay-Cross apparatus**
- Film oxygenator, was capable of good oxygenation, but both, being nondisposable, cumbersome to use, large priming volumes, very difficult and tedious to clean and sterilize, and rapid loss of efficiency if hemodilution was attempted.
- Disc oxygenation was later supplanted everywhere by bubble oxygenation (more efficient, safer, ideally adapted for hemodilution, yet vastly simpler to use and less expensive than the filming units.)

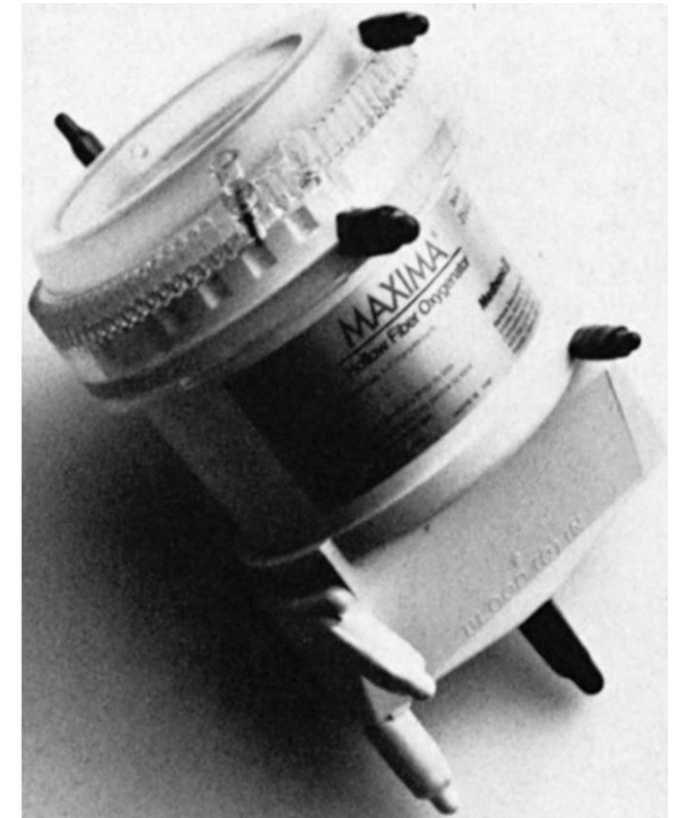




Membrane Oxygenators



- **Kolff** et al. described a disposable membrane oxygenator for experimental use in 1956.
- **Clowes and Neville** described their experimental studies with membrane oxygenation and a complex apparatus they considered suitable for clinical perfusions in 1958.
- With perfusions lasting 6 to 8 hours, the membrane oxygenator is associated with less reduction of platelets, less complement activation, less postoperative bleeding, and fewer microemboli





Hemodilution

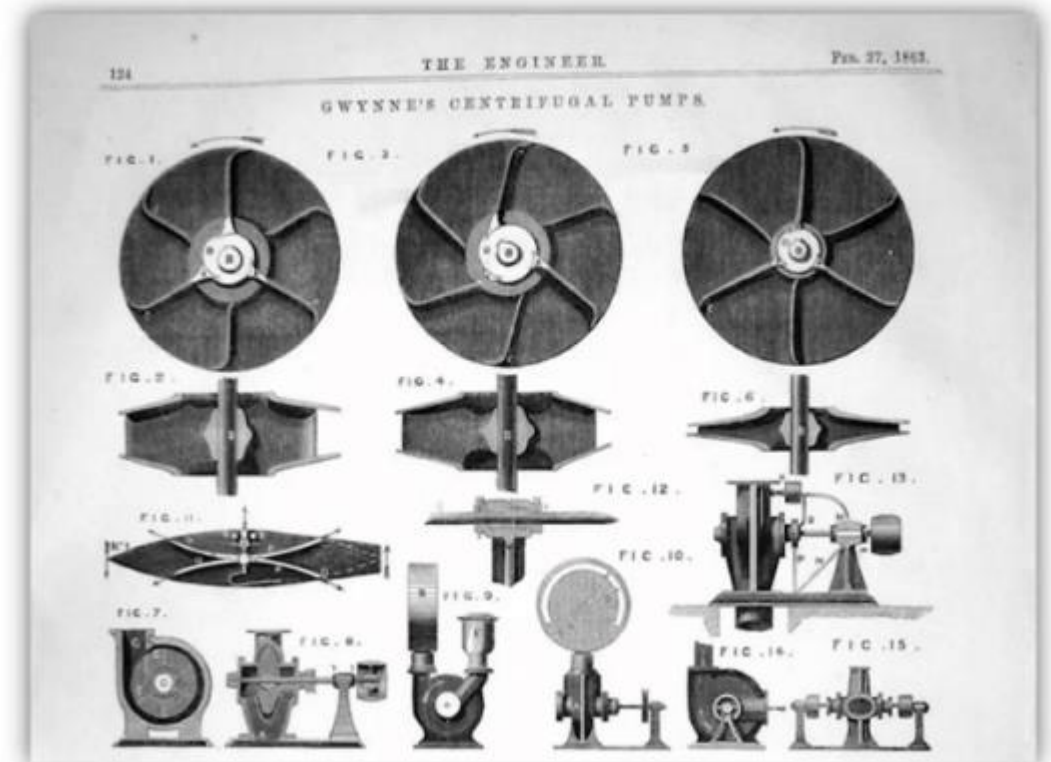


- A major technologic advance that the pump oxygenators could be primed with nonblood solutions
- Thereby immensely reducing the need for blood donors and at the same time improving the quality of perfusions by a reduction in viscosity and the safety by reducing foreign blood.
- **Zuhdi** et al. developed the theory and process of hemodilution in 1961
- DeWall et al. confirmed the benefits of hypothermic hemodilution in ECC.

Centrifugal Pump

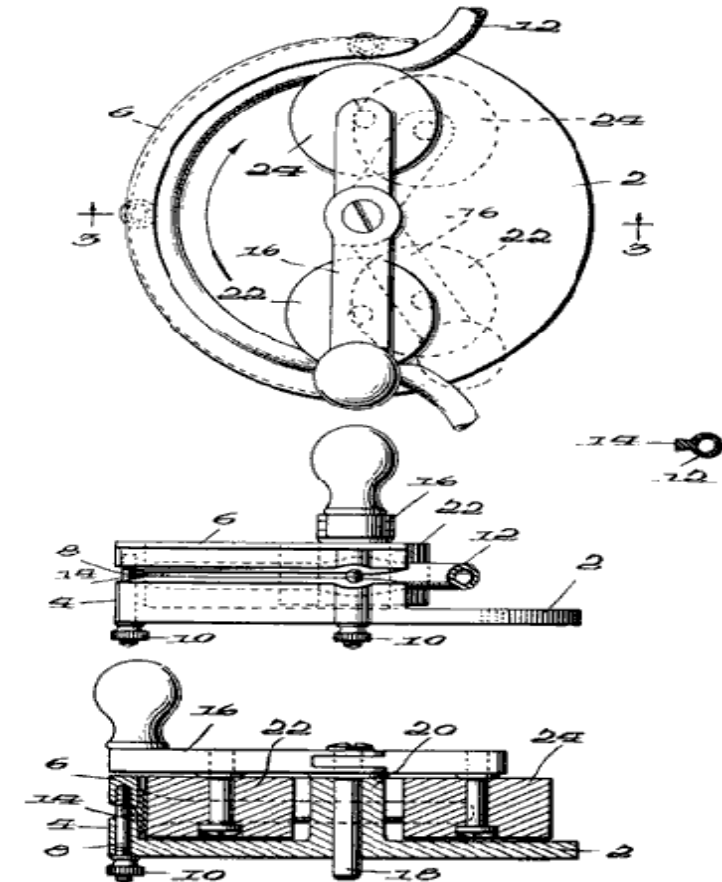
- The centrifugal pump described by **Rafferty et al.** in **1968** has become commercially available as the BioMedicus Biopump
- Advantages of this pump are reliability, ease of use over a wide range of flows, less likelihood to pump air, absence of spallation, and low hemolysis.

History of Centrifugal Pumps



Roller Pump

- The first roller pump was patented in **1855** by **Porter and Bradley**
- In **1887**, **Allen** patented a pump designed for blood transfusion
- In **1934**, **DeBakey** et al. made a modification to the Porter-Bradley infusion pump
- **1959**, **Melrose** proposed a more advanced design, in which the roller ran along the tubing held in place by a grooved backplate
- Simplicity, low cost, ease and reliability of flow calculation, and the ability to pump against increased resistance without reducing flow.





Assessment



- Who patented roller pump first time?
- Advantages of centrifugal pump

Heart Transplant

- By **1967**, the ultimate landmark of successful human heart transplantation was reached by two surgeons, **Dr. Barnard and Shumway**
- **Dr P. Venugopal** along with 20 surgeons successfully performed **India's first heart transplant** at the AIIMS on **3 August 1994**



Dr Christian Barnard



Norman Shumway

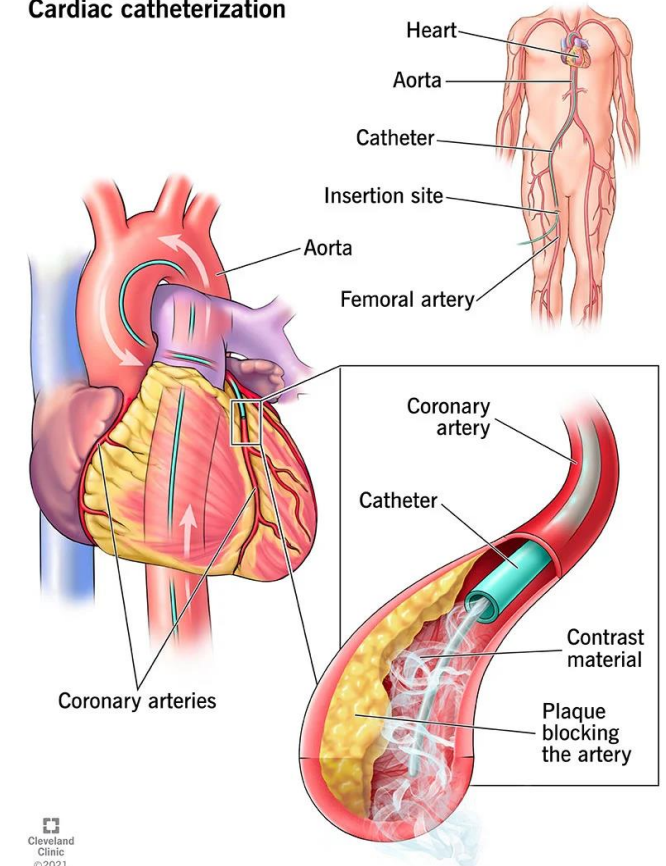


Dr P. Venugopal

Cardiac Catheterisation

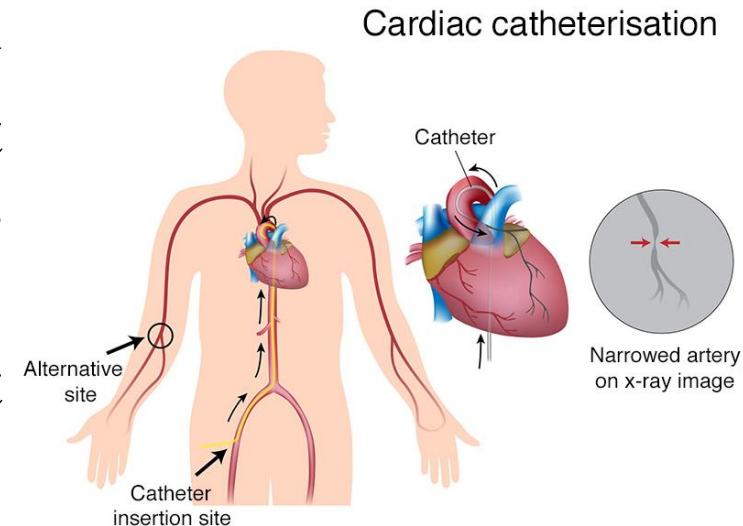
- In **1711**: development of cardiac catheterization
- **Stephen Hales** placed catheters into the right and left ventricles of a living horse
- In **1840s**: formal study of cardiac physiology being performed by **Claude Bernard**
- Cardiac catheterization is a procedure in which a thin, flexible tube (catheter) is guided through a blood vessel to the heart to diagnose or treat certain heart conditions, such as clogged arteries or irregular heartbeats.

Cardiac catheterization



Catheterisation in Humans

- In **1927**: The technique of angiography itself was first developed by the Portuguese physician **Egas Moniz** at the University of Lisbon for cerebral angiography
- In **1929**: Coronary catheterization was first performed by **Werner Forssmann**, created an incision in one of his left antecubital veins and inserted a catheter into his venous system
- He then guided the catheter by fluoroscopy into his right atrium





Summary



- 1855 - Porter and Bradley patented first roller pump
- 1916 - Jay Mclean discovered Heparin
- **1929 - Werner Forssmann** Coronary catheterization was first performed
- 1934 - DeBakey made a modification to the Porter-Bradley infusion pump
- 1951 - Dr. Clarence Dennis first operation performed using cardiopulmonary bypass and open cardiotomy
- 1952 - Dr. F. John Lewis closed ASD using inflow stasis and moderate total body hypothermia.
- 1953 - Dr. John Gibbon successfully complete the first open-heart operation.



Summary (cont)



- 1954 - Dr. C. Walton Lillehei 1st surgical closure of VSD under controlled the Cross circulation
- 1955 - DeWall and Lillehei began routine clinical use of a simple disposable bubble oxygenator
- 1956 - Dr. Frederick Cross along with Earl Kay developed a rotating disc oxygenator.
- 1961 - Zuhdi et al. developed the theory and process of hemodilution
- 1966 - DeWall introduction of a hardshell bubble oxygenator with an integrated oxygenator and omnithermic heat exchanger
- 1967 - Dr. Barnard and Shumway successful human heart transplantation
- 1994 - Dr P. Venugopal successfully performed **India's first heart transplant**



Assessment



1. Who invented heart lung machine?
2. Pioneers of Hypothermia
3. First surgery using heart lung machine
4. Why membrane oxygenators are better than bubble oxygenators?
5. Who discovered Heparin?



References



- Cardiopulmonary Bypass Principles and practice Glenn P. Gravlee
- Cardio Pulmonary Bypass Sunit Ghosh Florian Falter Albert C. Perrino
- <https://www.slideshare.net/drrakeshchoudhary/principles-evolution-of-cpb>
- <https://www.slideshare.net/donamathew731/history-of-cardiology>



THANK YOU