SNS COLLEGE OF ALLIED HEALTH SCIENCES

SNS Kalvi Nagar, Coimbatore - 35

Affiliated to Dr MGR Medical University, Chennai

DEPARTMENT OF CARDIO PULMONARY PERFUSION CARE TECHNOLOGY

COURSE NAME : PRINCIPLES OF PERFUSION TECHNOLOGY I

II nd YEAR

TOPIC : HISTORY OF EVOLUTION OF CPB

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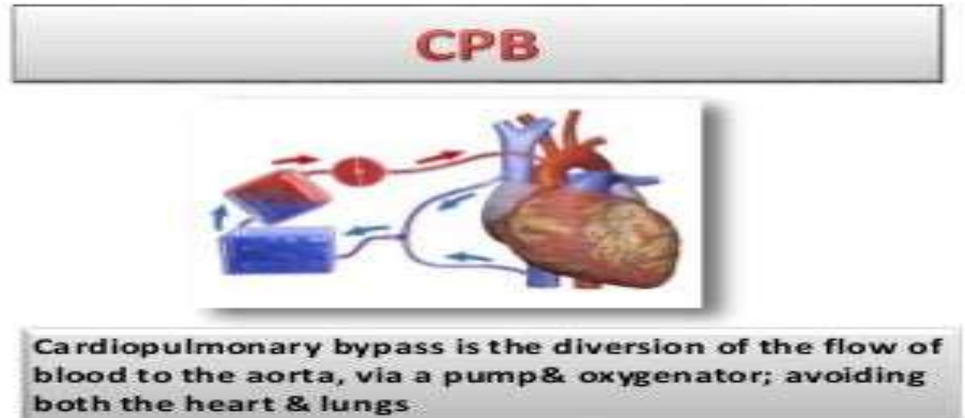
CPB

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

- Mechanical pumps acts as a heart while the human heart is arrested and the extracorporeal gas exchange device acts as a lung to artificially arterialized the venous blood
- Each of these mechanisms was established separately through animal experiments over the course of slightly more than 100 years



Evolution of CPB

- Temporary interruption of venous return to the heart _ 1812
- Blood groups A, B , O - 1858
- Anticoagulation (Heparin) - 1916
- Anticoagulant antagonist (Protamine)
- Roller pump - 1934
- Correlation between body temperature and metabolic rate

Scientific discoveries

- In **1928 Dale & Schuster** described the **prototype pumping mechanism** (Valved pump)
- In **1934 DeBakey** modified the **twin roller pump**
- **Bigelow ,Boerema, Lewis and Swan – pioneers of Hypothermia**

Inventions

- Dr. John Gibbon developed a **heart-lung machine** that he used in 1953 to successfully complete the first open-heart operation. Because of the development of the heart-lung machine, surgeons were able to perform surgeries previously considered too risky.He was 1st to succeed in using total extracorporeal circulation to facilitate the cardiac surgery.
- **In May 20, 1953 Celia Bavolek** 1st patient to undergo open heart surgery using CPB to repair an **Atrial Septal Defect (ASD)**

GIBBON'S INVENTIONS

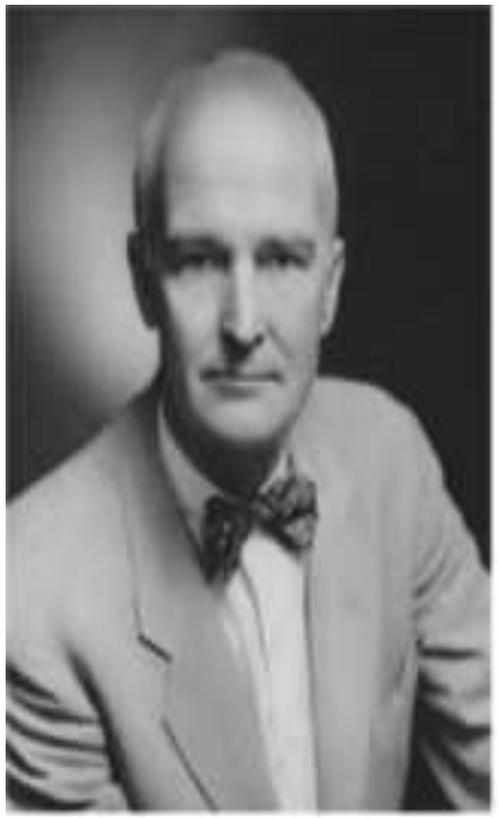
- Gibbon's initial laboratory models of blood oxygenators relied on rotating cylinders to spread in the thin film. The clinical model built with the technical support from IBM(International Business Machines) and its soon adopted by the **Kirklin's group at Mayo Clinic.** It was a **Film type Oxygenator**
- The primary problem with this design was blood streaming which caused a constantly diminishing **blood gas exchanging area**

Important contributions of Gibbon in CPB

- **Rinsing of the circuit** before CPB
- Use of **colloids for priming** solutions
- Small priming volume to **reduce hemodilution**

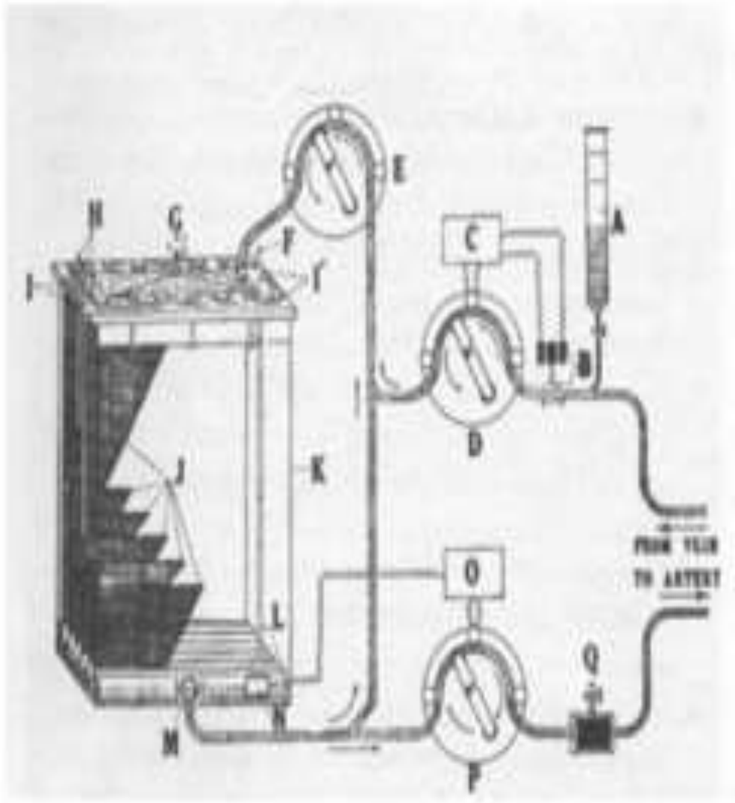
- Importance of measuring O2 saturation of venous blood to assess **tissue perfusion**
- Systemic pressure to be maintained at least **50 – 65 mmHg**
- Perfusate and blood trapped should be **salvaged** and returned to patient
- His equipment included **safety devices** for shutting off the pump automatically 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
- 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



A

B



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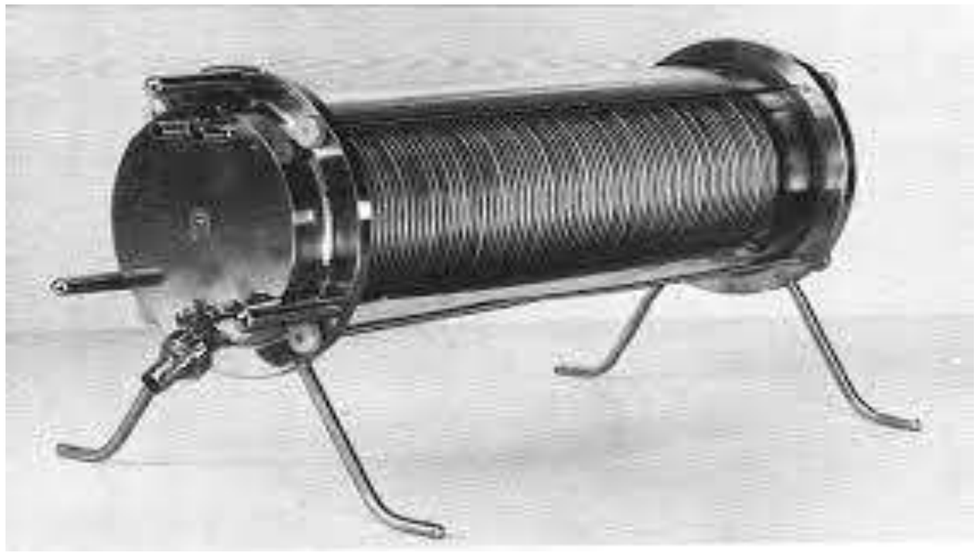


1955: Mayo Clinic-Gibbon heart lung machine
(screen oxygenator + rollar pump). This model was used in first series of open heart operations performed by Dr. John Kirklin and associates at the Mayo Clinic

Kay and Cross

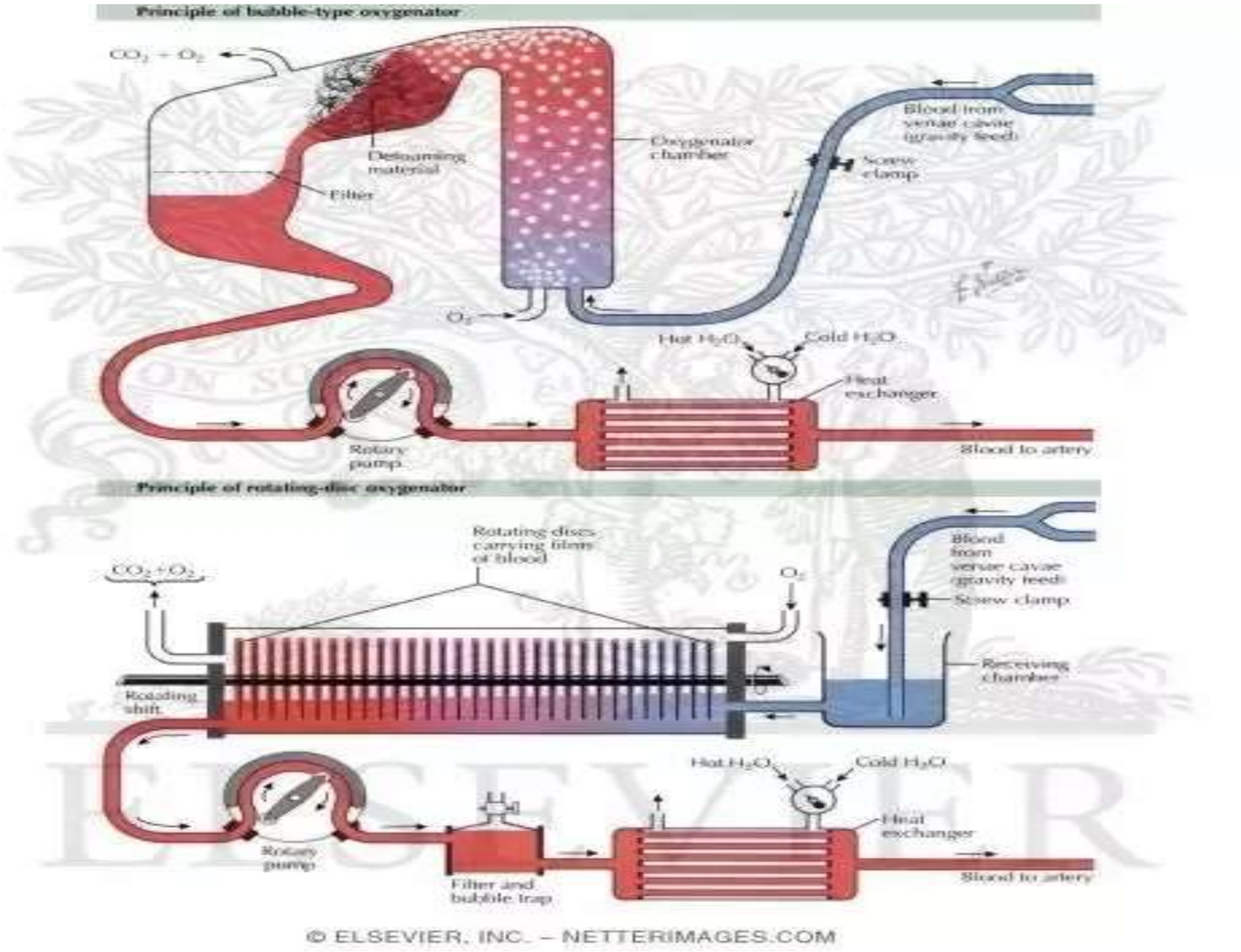
- Bjork worked on the first disc oxygenator in 1948, but Kay and Cross were the ones to enhance it and improve its effectiveness in 1956 . Disc oxygenators were an important landmark in the evolution of CPB, and their efficiency ensured they remained in use well into the 1970s.
- Then the advent of bubble oxygenator had came .

Bubble Oxygenator

- A bubble oxygenator was introduced in **1950** by **Clark, Gollan, and Gupta.**
- The first attempt was to add the O2 and removal of CO2 through a stationary blood pool
- Major advantages propelled bubble oxygenators ahead of Film oxygenators in the pioneer decade of cardiac surgery are
- Identification of silicone based deforming compounds
- Small bubble favor oxygen transfer because of their large over all exchange surface and large bubbles are needed for carbon dioxide removal because of their large carries gas content .
- When the venous blood is spread on top of the foam in the gas exchange column of an oxygenator , gas transfer is mediated by spreading a continuously renewed blood film that cascades down the foam surface. CO2 is effectively removed because of their large size of the gas cells in the foam and the process is apparently gentler to blood elements than bubble oxygenator

Bubble oxygenator (cont)

- Surgical resident **Vincent Gott** simplified the design of the oxygenator by heat-sealing the vertical mixing tube, de-bubbling chamber, and inclined settling columns between **two sheets of polyvinyl plastic**. Plastic tubing carried the exchange of deoxygenated and oxygenated blood between the oxygenator unit and the patient. The unit was designed to hang from a scale to assess blood volume, and could simply be discarded after use.
- Disposable oxygenators came to dominate the field of CPB from 1960 to the early 1980


Principle of bubble-type oxygenator
$CO_2 + O_2$
Defoaming material
Filter
Oxygenator chamber
Blood from venae cavae (gravity feed)
Screw clamp
O_2
Hot H_2O
Cold H_2O
Heat exchanger
Rotary pump
Blood to artery
Principle of rotating-disc oxygenator
Rotating discs carrying films of blood
$CO_2 + O_2$
O_2
Blood from venae cavae (gravity feed)
Screw clamp
Receiving chamber
Rotating shaft
Hot H_2O
Cold H_2O
Heat exchanger
Rotary pump
Filter and bubble trap
Blood to artery
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1953:Walton Lillehei's heart-lung-machine
bubble oxygenator (DeWall oxygenator)
Sigmamotor pump disposable plastic tubing inexpensive

Roller Pump

- In the same period roller pumps replaced all other mechanisms as the blood propulsion device for the clinical heart lung machine
- The higher flow capacity necessary for extracorporeal circulatory support without unacceptable blood damage was made possible by the adaption of the early design roller pumps.
- It includes a large bore flexible tubings, long , circular pumping chambers in over dimensioned housing and fast , controllable rate of revolution of the rotor assembly.

- First patented by **Porter and Bradley** in **1855**
- In **1934 DeBakey** et al made a modification to the **Porter Bradley infusion pump**
- In **1959 Melrose** proposed a more advanced design in which the roller ran along with the tubing held in place by grooved backplate.

Cross circulation

- In 1954 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

March 26, 1954:

University of Minnesota Medical Center, during the **first controlled cross-circulation operation**.

VSD was successfully visualized by ventricular cardiotomy and closed in a 12-month-old infant. The lightly anesthetized donor (patient's father) with the groin cannulations serving as the extracorporeal oxygenator. The VSD was closed by direct suture during a bypass time of 19 minutes.

Cardiac Catheterization

- First performed by **Forssmann in 1927** and then by **Cournand , Dickinson and Richards in 1954**, cardiac catheterization allowed the precise anatomic diagnosis of congenital or acquired cardiac lesions .

Deep Hypothermia

- **Deep hypothermia** served to lower body temperature and metabolism and allowed a period of circulatory arrest
- Feasibility and applicability of hypothermia for cardiac surgery was first suggested by Bigelow and colleagues in 1950

Hemodilution

- The circuit is deaired with the priming solution so that the hemodilution will occur.
- Eventually during those days blood banks could no longer supply all the blood requested for the growing number of cardiac procedures.
- Proper hemodilution shows the improvement in tissue capillary perfusion.
- Hemodilution was combined with hypothermia in order to attenuate the increase in blood viscosity at lower temperatures.

Membrane Oxygenator

- 1944,Kolff and Berk invented blood oxygenated when passed through cellophane chambers of artificial kidney.
- 1953, Gibbons, first successful open heart surgery with the use of artificial oxygenation and perfusion therapy.
- 1965, Rashkind Bubble oxygenator as support in neonate dying of respiratory failure.
- 1969, Dorson used the membrane oxygenator for CPB.
- 1970, Baffes successful use of ECMO as support in infants with congenital heart defect undergoing cardiac surgery.

Evolution Of Extracorporeal Circulation

- 1812 – Le Gallois showed that Extracorporeal circulation is possible
- 1858 – Brown – Sequard arterialized desaturated blood
- 1882 – First bubble oxygenator by Von Schroeder
- 1885 – First film oxygenator by Von Frey and Gruber
- 1890 – Jacob J described an device with a bubble oxygenator and bladder pump in order to provide pulsatile flow
- 1916 – Discovery of heparin by McLean
- 1934 – Debakey modified the twin roller pumps

BIRTH OF AN IDEA AND THE DEVELOPMENT OF CARDIOPULMONARY BYPASS

A PATIENT IN DISTRESS

- It was mid afternoon on October 3, 1930 and a patient at the Massachusetts General Hospital in Boston.
- For 2 weeks her convalescence from an uncomplicated cholecystectomy had been uneventful.
- she suddenly developed discomfort in her right chest, and immediately the discomfort gave way to sharp pain.
- Dr. Edward Churchill, who saw her at once in consultation, found her frightened, pale, cyanotic, cold, and moist.
- John H. Gibbon, Jr. was assigned the task of watching the patient and monitoring her vital signs

- He believed that the diagnosis of massive pulmonary embolism.
- she was moved to the operating room where pulmonary embolectomy done.

first attempts of cardiopulmonary bypass in the 1950s had series of disasters:

- everyone built his own device
- surgeons were inexperience with this new technology
  poor myocardial protection
  accidental intra operative air embolism
  postoperative bleeding
- only the sickest patients were referred to surgeons
- error rate in preoperative diagnosis was high

THE OPEN HEART ERA IS BORN

1952: **Dr. John Lewis**, after a period of laboratory research on dogs successfully closed a secundum ASD in a 5-year-old girl under direct vision using **inflow stasis** and moderate total body **hypothermia.**

- That was the world's first successful operation within the open human heart under direct vision.

1953: **Henry Swan**, at the University of Colorado, carried out his first open-heart procedure using **hypothermia**.

1959:Charles Drew, introduced '**deep hypothermia**'

- first successful repair of an atrial and ventricular septal defect under deep hypothermia.

University of Minnesota Hospital operating room on September 2, 1952 near the end of the **first successful open heart operation** in medical history.

Dr. F. **John Lewis** closed an atrial septal defect under direct visualization using inflow stasis and moderate total body hypothermia (26°C).

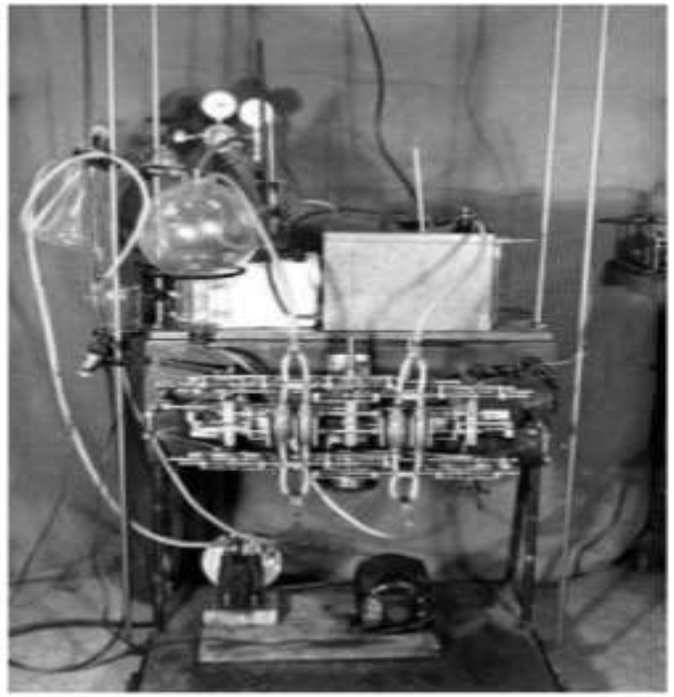
In a 5-year-old girl who remains alive and well today. Postoperative heart catheterization confirmed a complete closure.

Autogenous lung for cardiopulmonary bypass

Dodrill experience Autogenous lung bypass

- Dodrill et al. developed a blood pump for animal and clinical use as a right, left, or combined heart bypass with autogenous lung oxygenator.
- 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
- William T. Mustard used a monkey lung oxygenator



Cardiopulmonary Bypass

➢ Development

- **1951. Dodrill.** — **Mitral valve surgery under left heart bypass**
- **1952. Dodrill.** — **Relief of PS under right heart bypass**
- **1952. Lewis.** — **ASD closure under surface cooling**
- **1953. Gibbon.** — **ASD closure by heart-lung machine**
- **1954. Lillihei.** — **VSD closure under controlled cross-circulation**
- **1954. Kirklin.** — **Establishment of CPB with oxygenator in cardiac surgery**

THANK YOU