Clinical Engineering

Clinical Engineering Equipment (Heart-lung machines)

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Open Heart Surgery

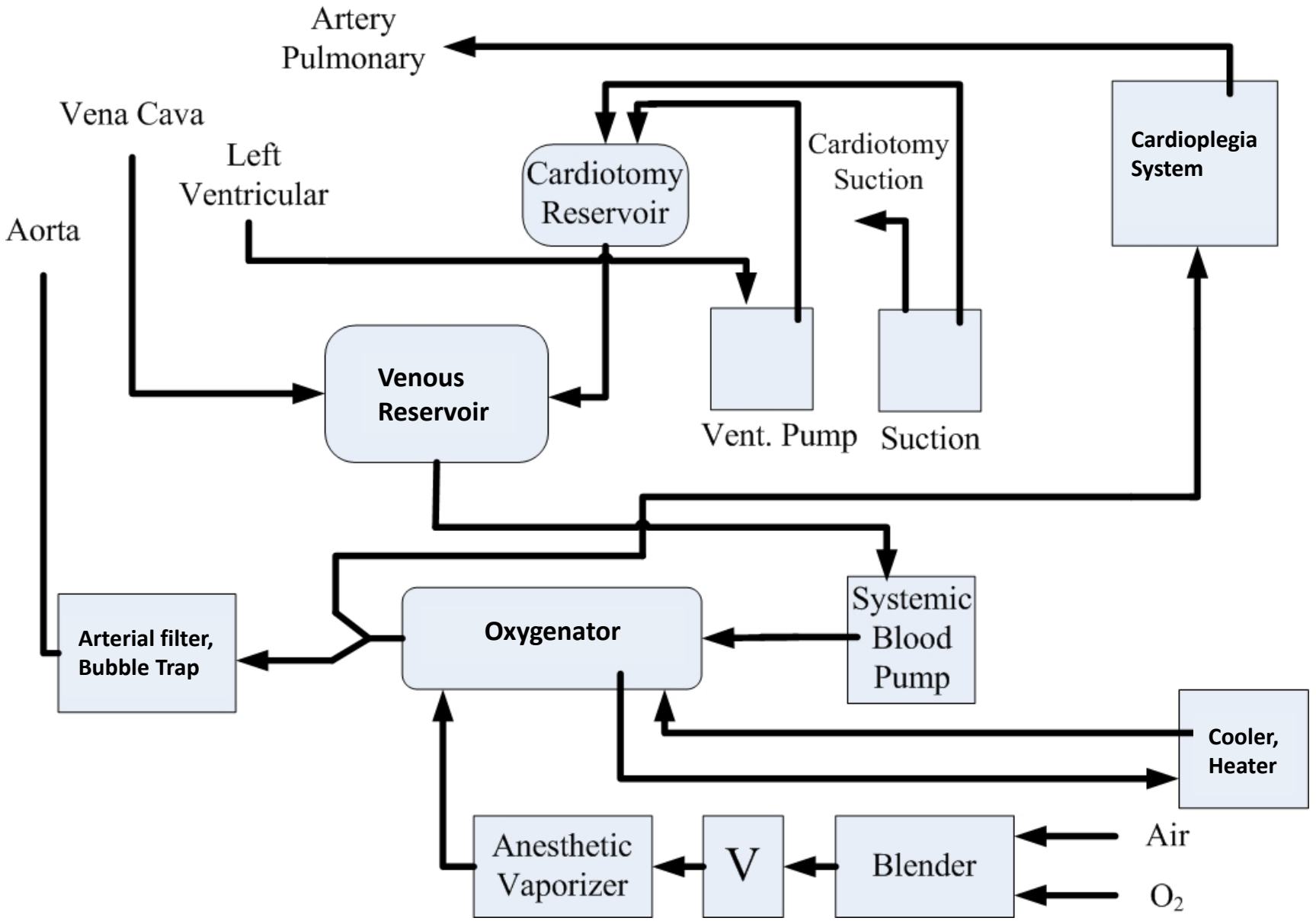
- Coronary artery bypass grafting (CABG)
- Repair or replace valves (Stenosis @ Regurgitation)
- Repair abnormal or damaged structures in the heart (Septum)
- Heart transplant

Heart-Lung Machine

- Cardiopulmonary bypass machine
- Provide blood flow and respiration for the patient while the heart is stopped
- Treatment provides removal of CO_2 from the blood, O_2 delivery to the blood, blood flow to the body + temperature maintenance
- Perfusion technologists

Heart-Lung Machine

- Component :
  - venous and arterial cannulae (tubes) – PVC @ silicone
  - venous reservoir
  - bubbler @ membrane oxygenator
  - heat exchanger / intercooler
  - cardiotomy reservoir
  - arterial line filter
  - pump
  - inline blood gas and electrolyte analyzer
  - pressure-monitoring devices


Artery
Pulmonary
Vena Cava
Left
Ventricular
Aorta
Cardiotomy
Reservoir
Cardiotomy
Suction
Cardioplegia
System
Venous
Reservoir
Vent. Pump
Suction
Arterial filter,
Bubble Trap
Oxygenator
Systemic
Blood
Pump
Cooler,
Heater
Anesthetic
Vaporizer
V
Blender
Air
O_2

Oxygenator

- Serves as the lung (expose the blood to oxygen) + disposable + 2-4 meters squared of membrane (permeable to gas & impermeable to liquid blood)
- Oxygen gas is delivered to the interface between the blood and the device, permitting the blood cells to absorb oxygen molecules directly
- Carbon dioxide is added to the sweep stream to maintain the proper blood gas level
- Type : Bubble @ Membrane

Bubble oxygenator

- O_2 and venous blood enter oxygenator
- O_2 bubbles mix with ascending blood stream and gas exchange occurs
- At the top of the column, the gases and blood form a foam from which the bubbles coalesce
- Oxygenated blood contacts chemical defoamer and exhaust gas is expelled
- Oxygenated blood leaves oxygenator before going on to filters and bubble traps

Membrane oxygenator

- venous blood enters oxygenator
- exchange takes place across membrane
- arterialised blood is collected in the outlet manifold and returned to the patient
- eliminates the need for a bubble blood contact & need for a defoamer
- ideal for perfusions lasting for > 2-3 hours
- 2 type of membrane
  - solid-silicone
  - microporous – polypropylene /teflon/polyacrylamide
- Heparin-coated oxygenators

Comparison of oxygenator

Bubble	Membrane
Advantage : • cheap • easier to set-up • relatively small primimng volumes • adequate oxygenating capacity	Disadvantage : • expensive • longer time to set up • large priming volume • prolonged used - pores may get blocked

Comparison of oxygenator

Bubble	Membrane
Disadvantage : • increased risk of gaseous embolism and thrombosis • poor compatibility • long post operative recovery course • blood cell trauma • destruction of plasma protein due to gas interface • excessive removal of CO2 • defoaming capacity may get exhausted with time • cannot use for extended CPB times	Advantage : • less damaging the blood - better platelet preservation • can be used longer • shorter post operative recovery course (post-op bleeding) • can deliver air-O2 mixtures • decrease hemolysis • decrease protein desaturation

Pump

Roller @ peristaltic pump

- The pump console usually comprises several rotating motor-driven pumps that peristaltically "massage" the tubing
- This action gently propels the blood through the tubing

Centrifugal pump

- Many CPB circuits now employ a centrifugal pump for the maintenance and control of blood flow during CPB.
- By altering the speed of revolution (RPM) of the pump head, blood flow is produced by centrifugal force.
- This type of pumping action is considered to be superior to the action of the roller pump by many because it is thought to produce less blood damage (hemolysis)

Cardioplegia system

- Cardio - heart & plegia - paralysis
- To accomplishing asystole - arresting or stopping the heart so that surgical procedures can be done
- How - mild hypothermia (34°C) + cold crystalloid cardioplegic solution (4 °C + dextrose, potassium chloride, and other ingredients) + via cannulae + at aortic roof