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 : OXYGENATOR

Oxygenator

- The oxygenator is designed to add oxygen and remove carbon dioxide from the venous blood.
- It used in two principle modes :

  CPB – Cardio pulmonary Bypass – Short term < 6 hrs

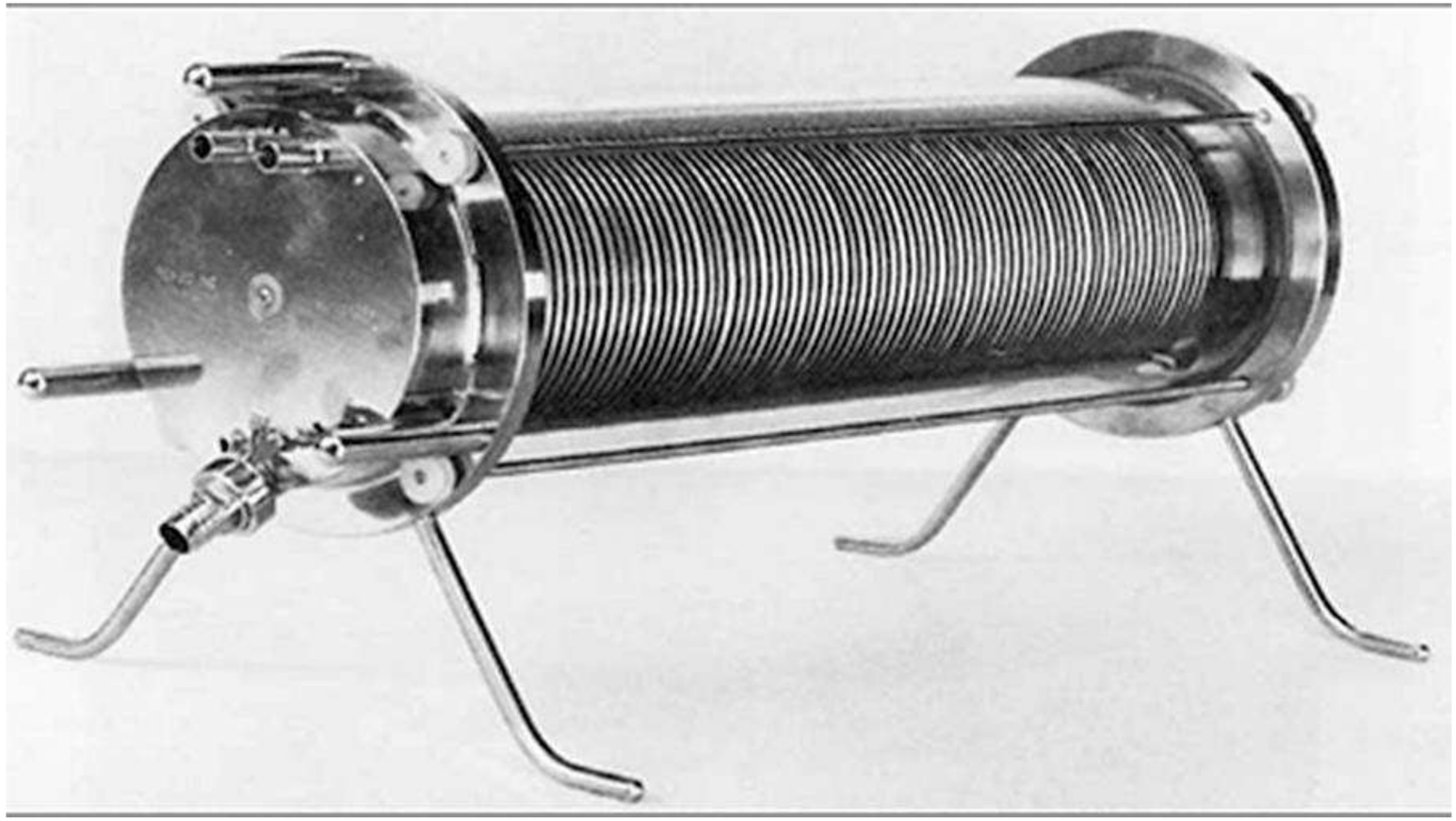
  ECMO – Extra corporeal membrane oxygenation – Long term >6 hrs

Types of oxygenator

- Film oxygenator
  - Rotating disc oxygenator
  - Vertical screen oxygenator
- Bubble oxygenator
- Membrane oxygenator

Film Oxygenator

- Introduced by Kay Cross
- It is a **horizontal pyrex glass cylinder** with stainless steel end plates.
- A **central axel** is rotated in a bearing set.
- It contains **stainless steel discs** with spaces between them , flat and convoluted.
- There is a direct contact of **blood and gas** in it



Film oxygenator

Vertical screen Oxygenator

- Cabinets containing a series of upright screen in an atmospheric oxygen.

- In this type of oxygenators, venous blood is introduced by the way of slits at the top of the cabinet

- Oxygenated blood collects at the bottom of the cabinet

Bubble Oxygenator

- It is introduced by De wall & Lillehei

Principle

- The blood enters in a venous inlet and crosses a heat exchanger, oxygen is then bubbled through this venous blood and gas exchange occurs.
- The oxygenated blood then flows through a defoamer and into the arterial reservoir.
- The arterial blood return to patient

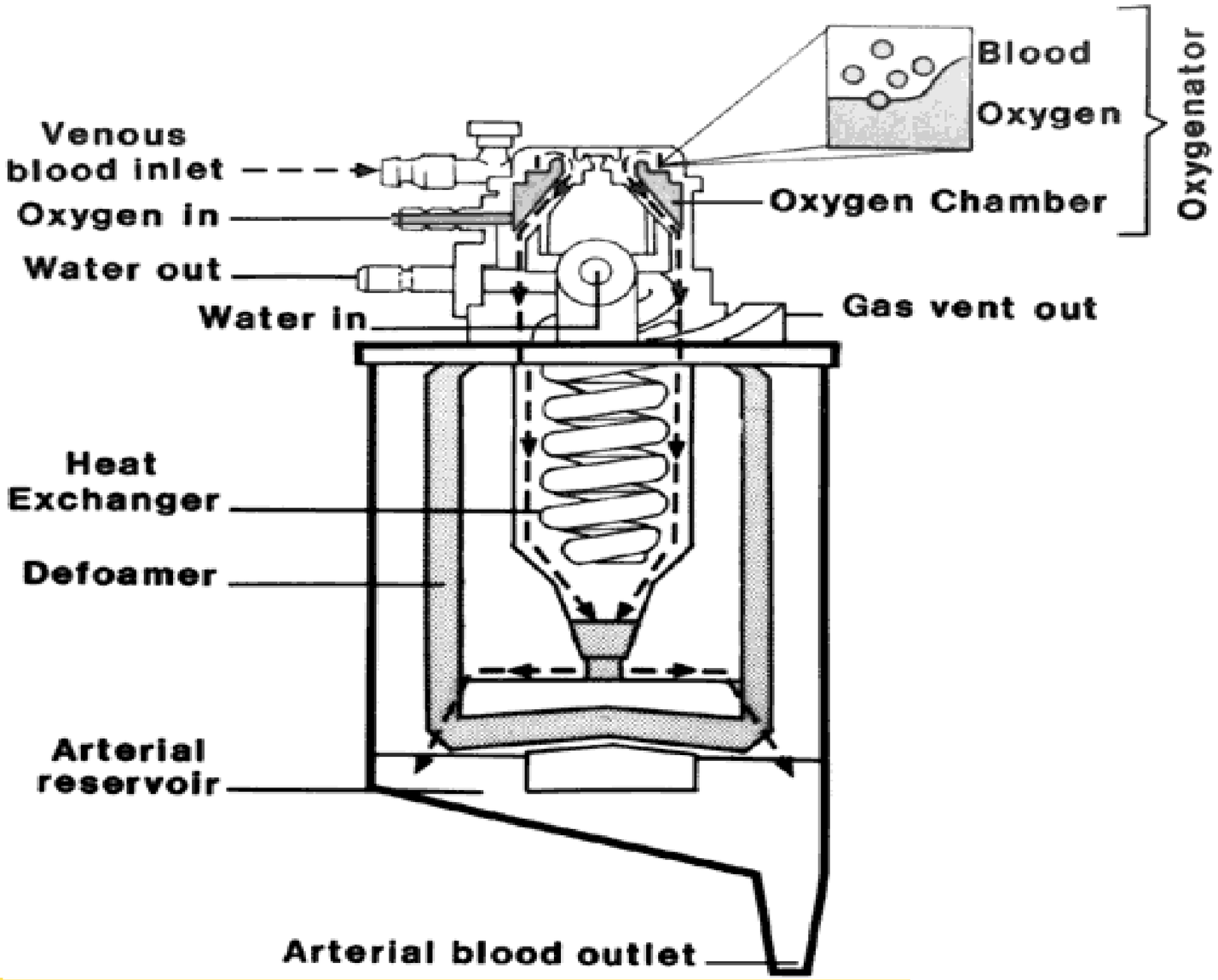
Bubble Oxygenator

- Bubble size is important for adequate gas transfer
- Small bubbles carries O2
- Large bubbles removes Co2
- Ideal bubble size for gas transfer is 3mm to 7mm.

Bubble Oxygenator

The typical bubble oxygenator is divided into two sections.

- The **first section** is the mixing chamber (Oxygen chamber), where fresh gas flows into the blood through a screen, Which causes small bubble to form.
- The oxygen is transferred from the bubbles into the blood, and carbon dioxide is transferred from the blood into the bubbles.
- The **second section** is the reservoir where blood defoaming and contain in it.


Blood
Oxygen
Oxygenator
Venous
blood inlet
Oxygen in
Oxygen Chamber
Water out
Water in
Gas vent out
Heat
Exchanger
Defoamer
Arterial
reservoir
Arterial blood outlet

Advantages of bubble oxygenator

- Easy to assemble
- Relatively small priming volume
- Adequate oxygenating capacity
- Lower cost
- Low resistance to flow

Disadvantages of bubble oxygenator

- Micro emboli
- Blood cell trauma
- Excessive removal of Co2
- Destruction of plasma protein due to gas interface
- Defoaming capacity may get exhausted with time

Ideal characteristics of oxygenator

- Oxygenation of venous blood
- Carbon dioxide elimination (Excellent gas exchange)
- Minimum blood trauma
- Small priming volume
- Easily assembled and safety
- Minimal failure incidents and easy to replace during cardiopulmonary bypass in the event of oxygenation failure
- Ease of use – Transparent to visualization of air, easily changeable in case of emergency

Membrane Oxygenator

Natural lung	Membrane oxygenator
More surface area It has a surface area of 70m2	Less surface area It has a surface area of 0.5- 4.0 m2
O2 transfer 2000ml/min	O2 transfer 200 – 600 ml/min
Length 200µ m	Length of blood path increases to get fully oxygenation, so it is 2,50,000 µ m
Membrane thickness 0.5 µ m Blood path width 8 µ m	Membrane thickness 150 µ m Blood path width 200 µ m

Membrane oxygenator

- It physically **separates the blood from gas** with the gas permeable membrane material

- Membrane oxygenator consists of three parts

Venous reservoir

Oxygenator

Heat exchanger

Membrane oxygenator

Membrane material

Silicone rubber

It is Homogenous

Non Porous material (True membrane)

Used in ECMO

Polypropylene

It is Heterogenous

Microporous hydrophobic membrane

Used in CPB

True Membrane (Diffusion membrane)

- True membrane oxygenators are manufactured by coiling silicone rubber sheets in a cylindrical fashion (Silicone is a thermoset plastic ; It has a better dimensional stability , heat resistance , chemical resistance).

- Blood is kept on one side of the membrane and gas on the other side.

- The membrane provide a complete barrier between the blood and gas so that gas transfer depends totally on diffusion of gases through the membrane material

- It is costly and have large priming volume

True membrane

- It is used primarily in ECMO , because of it ability to maintain stable Co2 &O2 for long period of time without the decrement in gas transfer.
- The gas exchange surface area sizes from 0.5 – 4.5 m2 for ECMO.

Microporous membrane oxygenator

- It is made by stretching membrane material
- Pores are 0.03 µ m to 0.07 µ m
- It is a microporous hollow fiber

Microporous membrane oxygenator

- The membrane oxygenator is more biocompatible

- A non porous true diffusion membrane made from polymethyl pentene (PMP) is available & suitable for long term purpose (eg ECMO)

- But limit transfer of volatile anaesthetics and because of its higher cost these membrane is not used commonly

Types of membrane oxygenator

- Plague oxygenator
- Spiral Oxygenator
- Hollow fiber oxygenator

Plague Oxygenator

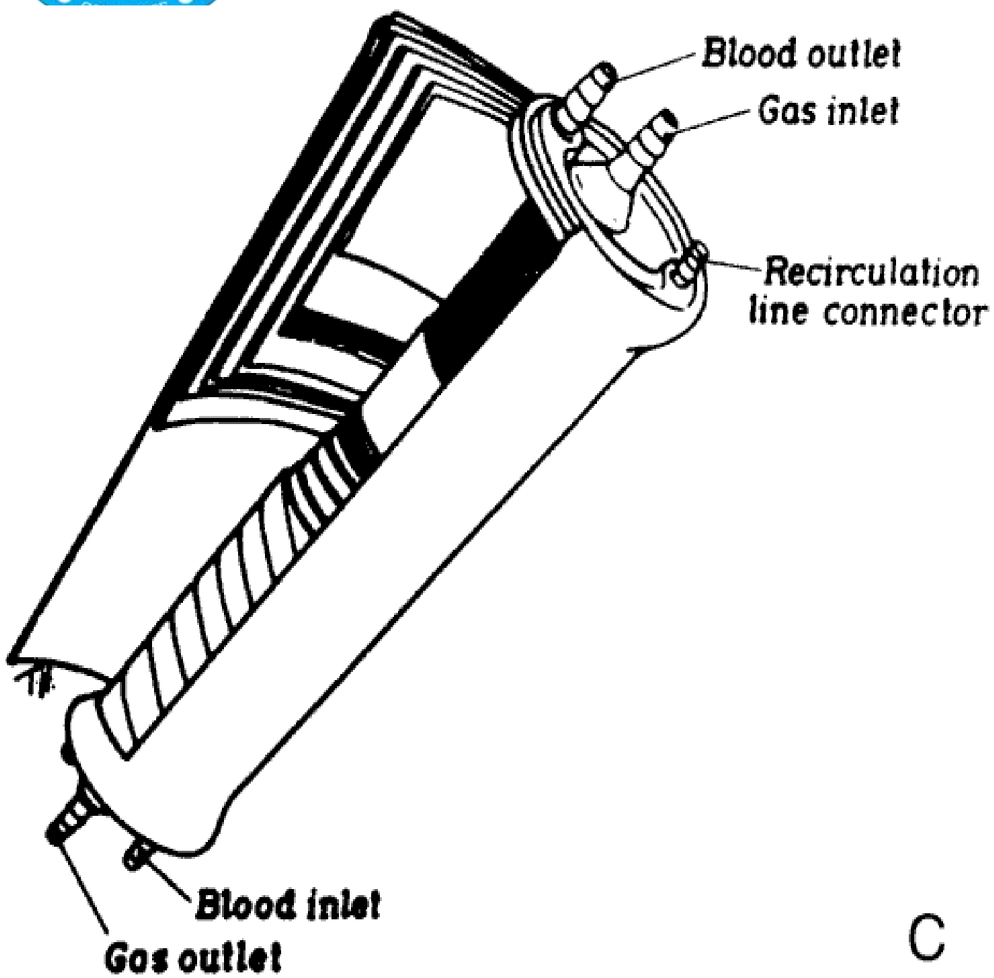
- They built with microporous membranes of expanded polypropylene folded in a ‘Z’ shaped.

- in this apparatus blood and gas flow in opposite side of the membrane.

Spiral Oxygenator

- They are the derivative of the old model of kolobow's oxygenator that utilized silicone membrane
- The membrane is rolled around a central axis.

Spiral Oxygenator



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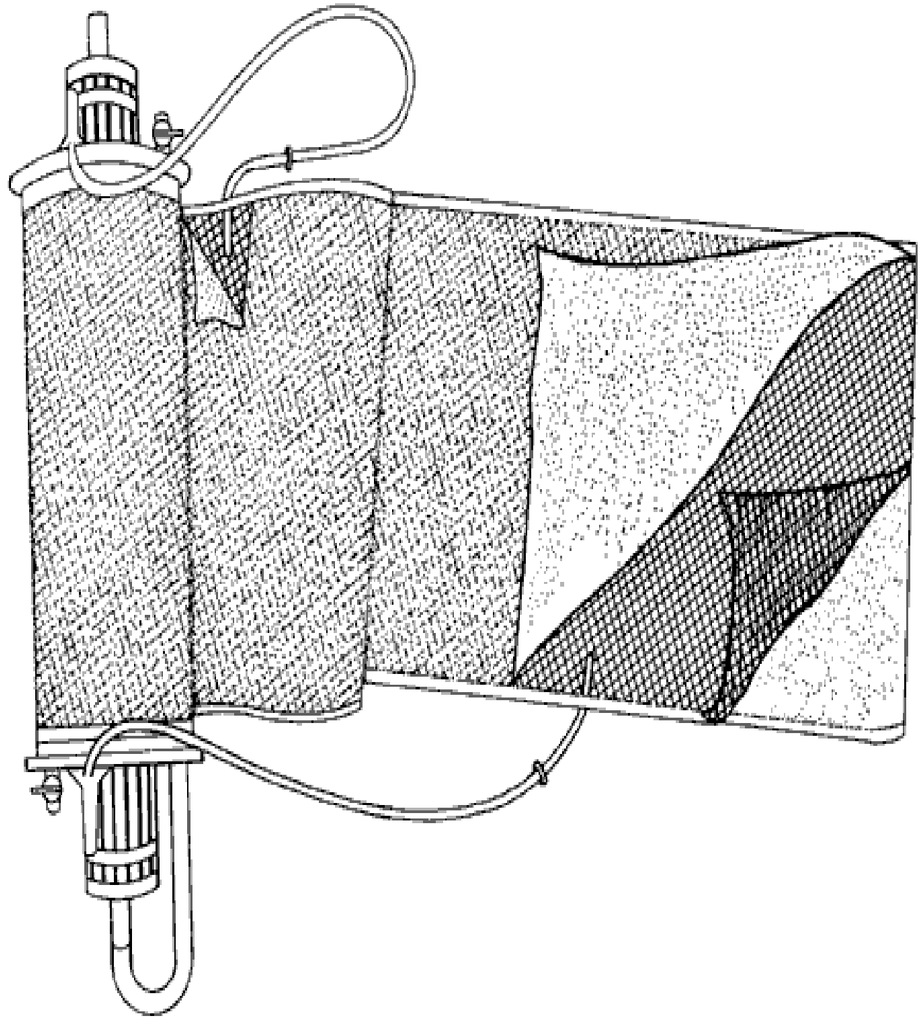
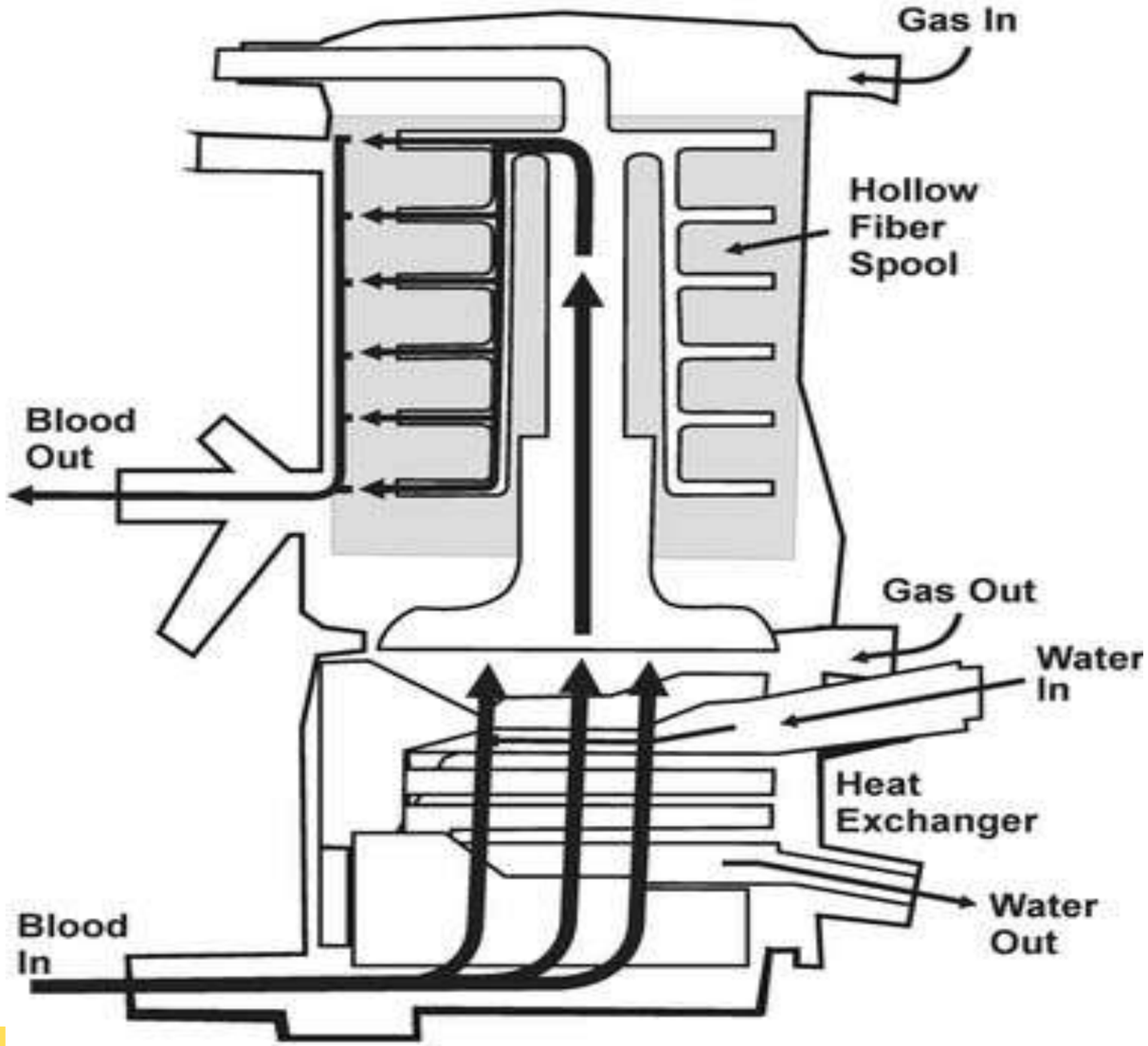


Hollow Fiber Membrane Oxygenator

- The microporous polypropylene hollow fiber is the most membrane oxygenators actually use.
- Blood inside fiber – Blood will spill to the gas phase, not allow visualization of air bubbles in blood path.
- Blood outside fiber – Allow visualization of air bubbles.
- Ports of membrane oxygenator – gas inlet and outlet, water inlet and outlet, venous inlet, oxygenator outlet, sampling port, cardiotomy and vent port, filtered and unfiltered port, purge port


Gas In
Hollow
Fiber
Spool
Blood
Out
Gas Out
Water
In
Heat
Exchanger
Water
Out
Blood
In

B

Oxygenators

Oxygenators requires gas supply by

- Blender
- Flow regulator
- Flow meter
- Gas filter
- Moisture trap
- Anaesthetic vaporiser