Introduction to ECMO

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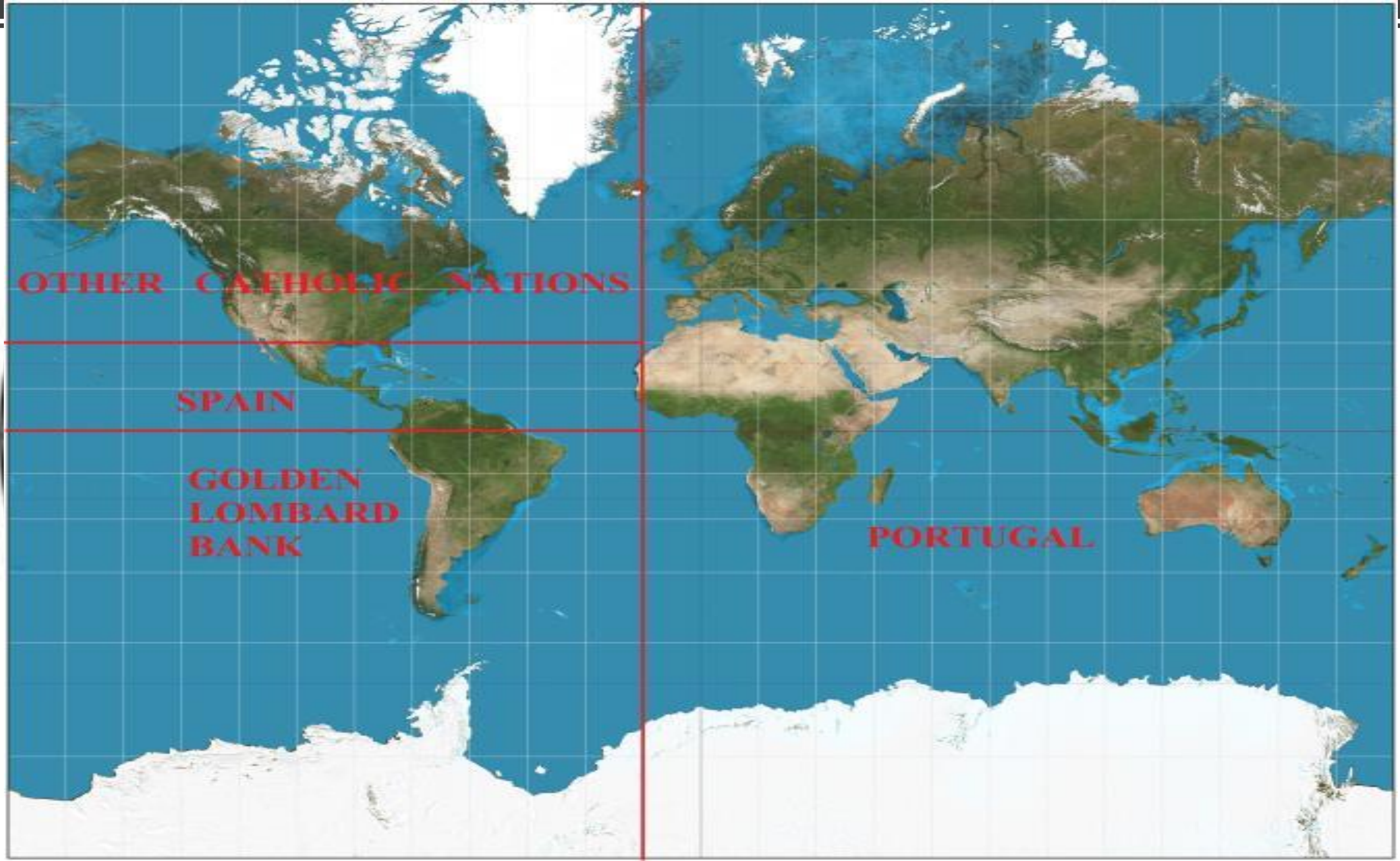
I HAVE NOTHING TO DISCLOSE!

BEFORE ECMO

SOME WORLD HISTORY AND TRIP AROUND THE GLOBE

Tordesillas Treaty-1494



Age of Discovery

- Henry The Navigator(Infante Dom Henrique)-1394-1460
- -King John I: Duarte,Pedro,Henrique
- Columbus:1492-1502
- -Vasco Da Gama(1497-1499)-sea route to India
- -Pedro Alvares Cabral(1500)-Brazil
- -Fernão de Magalhães(1519-1522)-around the world

Torre De Belém

Guinea-Bissau 1456

Tomar-Portugal-Order of Templars

Hospital De Santa Maria-Lisbon

Egas Moniz

FRONTAL LOBE LOBOTOMY-1935

NOBEL PRIZE MEDICINE-1945

ROSEMARY KENNEDY-LOBOTOMY(1941)

New York Hospital-Cornell

Memorial Sloan-Kettering Cancer Center

Stony Brook University Hospital

Bath and Bristol-England

The Alfred,Melbourne-Australia

University of Michigan


Oh yes, please
how hard your job is.

Introduction to ECMO

- 1-History
- 2-Current status
- 3-Membrane Gas Exchange
- 4-Oxygen Content, Delivery and Consumption

Acknowledgement

- Dr Robert Bartlett,MD, Michigan ECMO
- Dr Steven Conrad,MD, LSU Health Sciences Center

HISTORY OF ECMO AND CURRENT STATUS

History and Development of Extracorporeal Life Support

- 1667-Jean Baptiste Denys: Cross-transfusion of blood of a human with the “gentle humors” of a lamb,to determine if living blood could be transmitted between 2 species.
- (Antoine Mauroy)

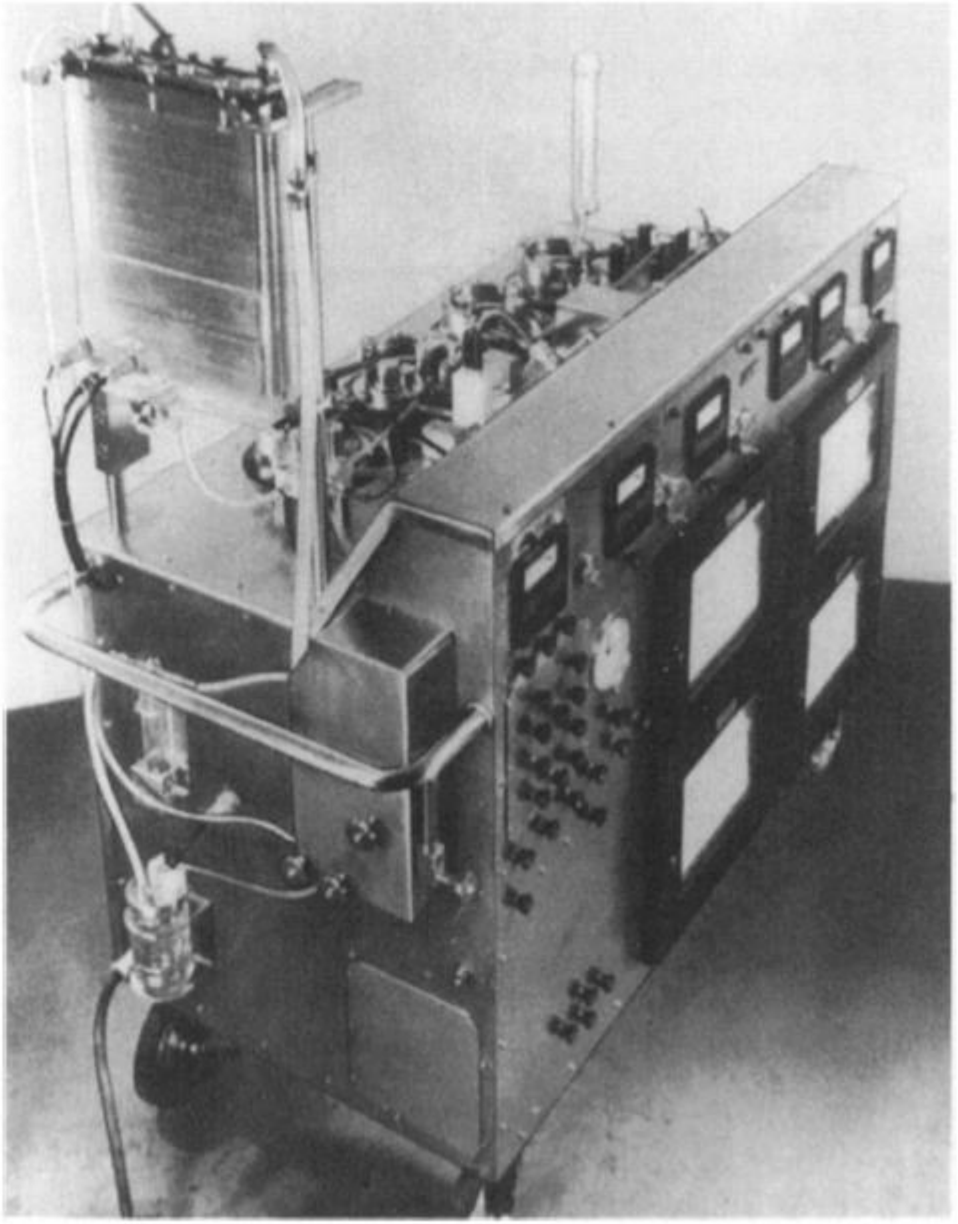
- 1860-Benjamin Ward Richardson: Injected 02 plus blood via a syringe to the RV to generate artificial circulation in an animal model.

- 1931-John and Mali Gibbon
- -Developped first CPB machine

- 1934-Debakey: Design of dual roller pump system

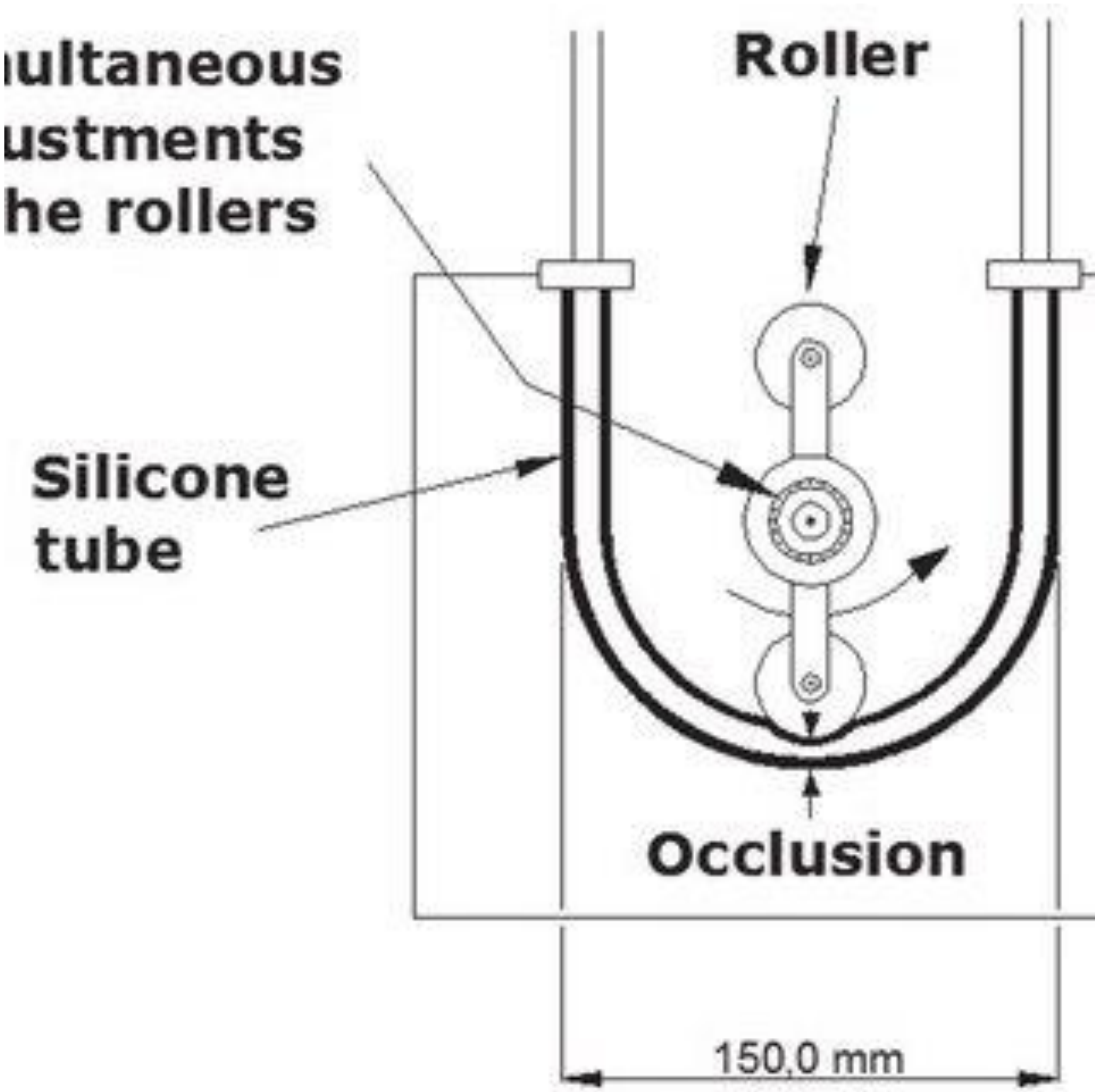
- 1953-John Gibbon
- -ASD repair on CPB(18 y/o patient)

First Cardiopulmonary Bypass Machine



Debakey

Roller Pump



OXYGENATOR(Late 1950's, Early 1960's)

- 1-Phil Drinker , Robert Bartlett(Boston Children's Hospital)
- 2-Theodor Kolobow(NIH)
- 3-J.D.Hill(San Francisco)
- 1968:P Drinker & Robert Bartlett: canines on ECMO

Theodor Kolobow

1971:Dr J.D Hill:

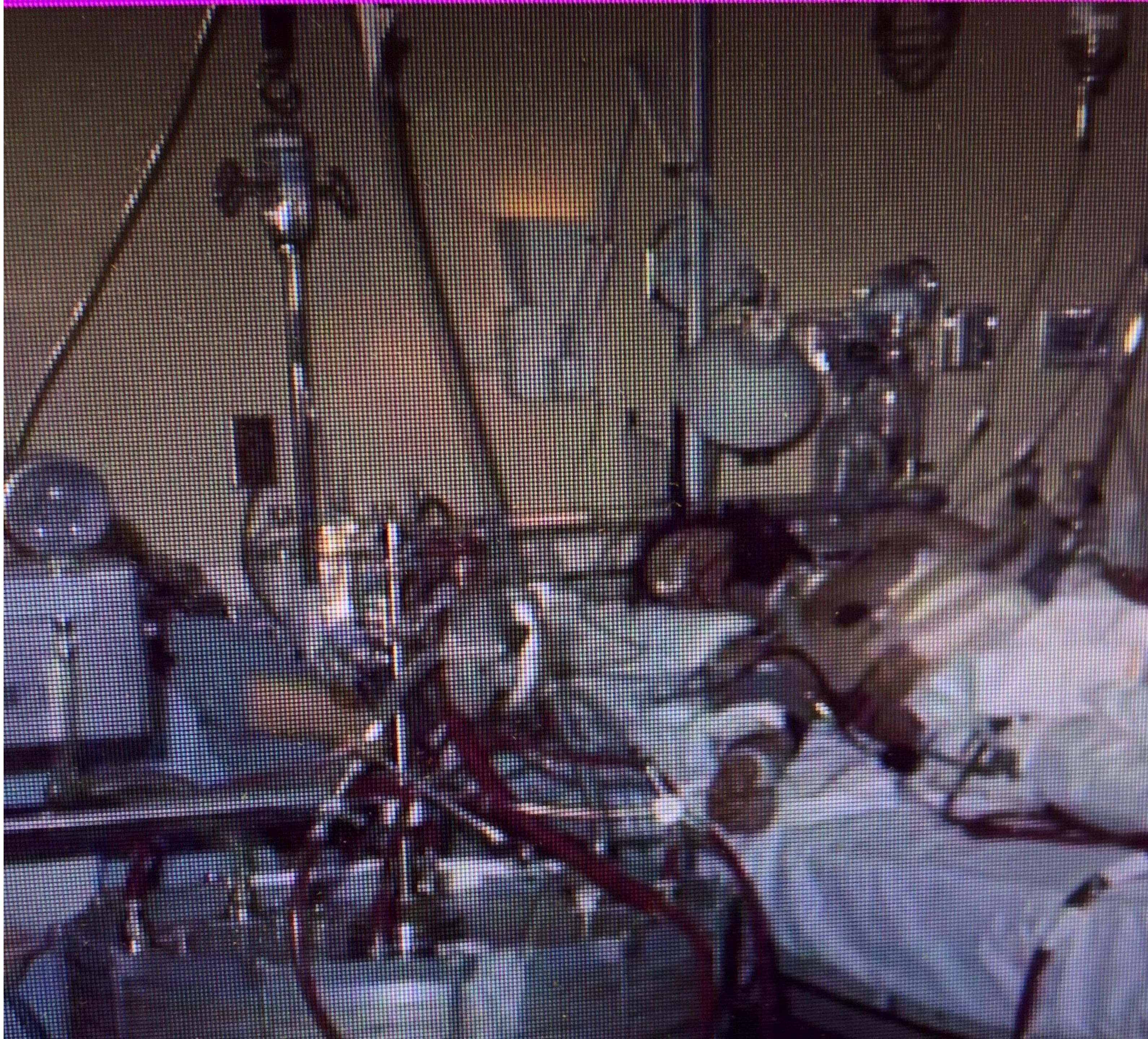
-Ecmo outside the OR

-24 y/o male with rupture aorta,post MVC:VA ECMO x 72 hours-survived

1972:Bartlett & Gazzaniga:

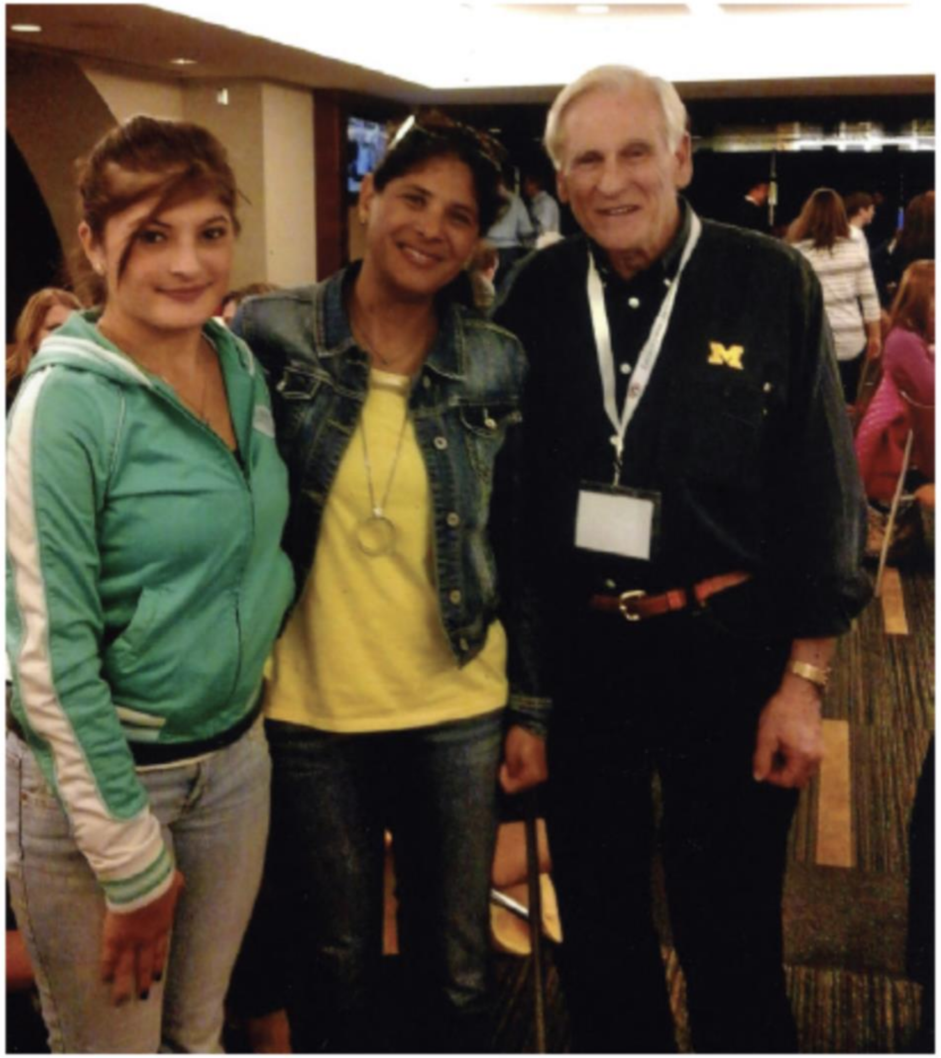
-First Pediatric cardiology case

-Mustard procedure in 12 year old-ECMO x 30 hours



- 1975-Robert Bartlett
- -First Neonatal case
- Baby Esperanza:72 hours

- Esperanza at 21



Trials

- 1993-1995
- UK trial for neonates: mortality-ECMO 30/93; conventional 54/92

1994: VA vs standard care-no difference

2001-2006: UK-Cesar trial(Giles Peek): VV ECMO for adults with respiratory failure; survival-ECMO 57/90; conventional 41/87

2009:H1N1

2018: EOLIA trial: ECMO mortality-35%; Conventional-46%

ELSO

- 1989- First ELSO meeting
- 1991-EuroELSO
- 2012-LAELSO
- 2014: APELSO
- 2013:South & West Asia ELSO

Chairs ELSO and Global ELSO Chapters:

Years	Chair
ELSO	
2016-2018	Michael McMullan
2014-2016	James Fortenberry
2012-2014	William Lynch
2010-2012	Steve Conrad
2007-2010	Mike Hines
2004-2007	Heidi Dalton
2002-2004	Joseph Zwischenberger
2000-2002	Ronald Hirschl
1997-2000	Charles Stolar
1994-1997	Michael Klein
1993-1994	Billie Lou Short
1989-1993	Robert Bartlett
Euro ELSO	
2014-2017	Roberto Lorusso
2012-2014	Giles Peek
Asia Pacific ELSO	
2013-2017	Graeme MacLaren
Latin American ELSO	
2015-2017	Luiz Caneo
2013-2015	Rodrigo Diaz/Javier Kattan (Co-chairs)
South and West Asia ELSO	
2018	Venkat Goyal
2017	Malaika Mendonca
2014 -2016	Suneel Poobani

- CURRENT STATUS

ECLS Registry Report

International Summary

January, 2017

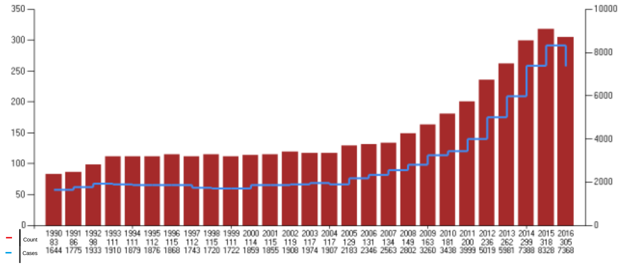
Extracorporeal Life Support Organization
2800 Plymouth Road
Building 300, Room 303
Ann Arbor, MI 48109

Overall Outcomes

	Total Runs	*Survived ECLS*		*Survived to DC or Transfer*	
Neonatal					
Pulmonary	29,942	25,205	84%	21,948	73%
Cardiac	7,169	4,643	64%	2,938	40%
ECPR	1,532	1,028	67%	627	40%
Pediatric					
Pulmonary	8,070	5,424	67%	4,632	57%
Cardiac	9,362	6,404	68%	4,758	50%
ECPR	3,399	1,958	57%	1,414	41%
Adult					
Pulmonary	12,346	8,242	66%	7,157	57%
Cardiac	10,982	6,251	56%	4,466	40%
ECPR	3,485	1,382	39%	993	28%
Total	86,287	60,537	70%	48,933	56%

Centers

Centers By Year



Steven Keller-Harvard Medical School-CCM 2019,Volume 47, Number 9

Present-day Intensivists, Surgeons , ICU Nurses face similar uncertainty in how to titrate support for ECMO as was confronted with the introduction of mechanical ventilation.

Lacking extensive animal data to inform practice, current ECMO demands that the health care providers applies physiologic principles to determine and guide support.

CARDIOPULMONARY PHYSIOLOGY

OXYGEN CONTENT, DELIVERY , CONSUMPTION AND EXTRACTION RATIO

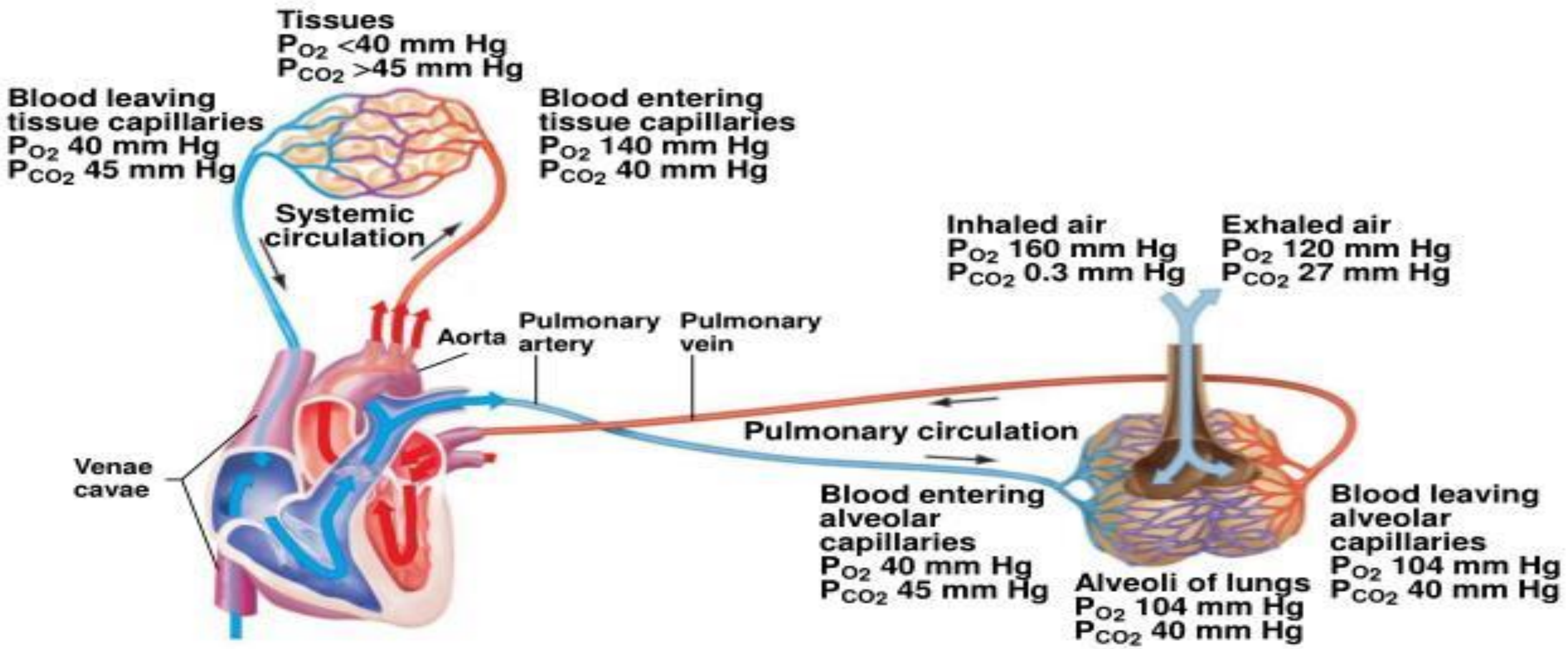
CardioPulmonary Physiology

- All tissues of the body function by:
- -combining substrates with oxygen,producing heat,energy,C02,and water-metabolism
- -D02:oxygen delivered per minute
- -V02 : measurement of oxygen consumed per minute
- --adults:3cc/kg/mn
- --children:4cc/kg/mn
- --infants:5cc/kg/mn

CardioPulmonary Physiology and Gas Exchange -Native Circulation

- A-Oxygenation
- -Oxygen partial pressure in the Oropharynx(159mmHg)
- -Alveolar(100mmHg)
- Capillaries(90-95mmHg)-venous mixture from returning systemic circulation
- Tissue capillaries-aerobic metabolism-Pv02=40mmHg(75%)
- SV02(75%)
- ScV02(upper body)-5-10% higher

Partial Pressures of Gases Vary throughout the Human Circulatory System



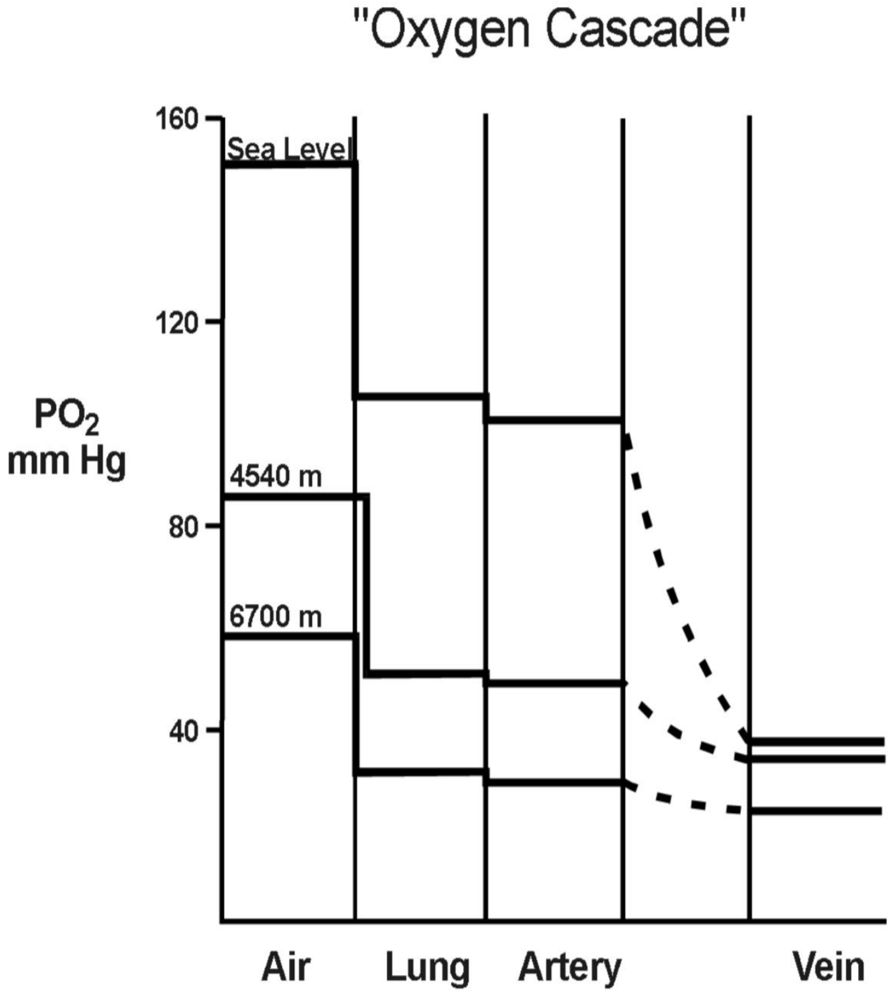
OXYGEN

- Oxygen is used in the Mitochondria for substrate oxidation, leading to production of energy and Carbon Dioxide.

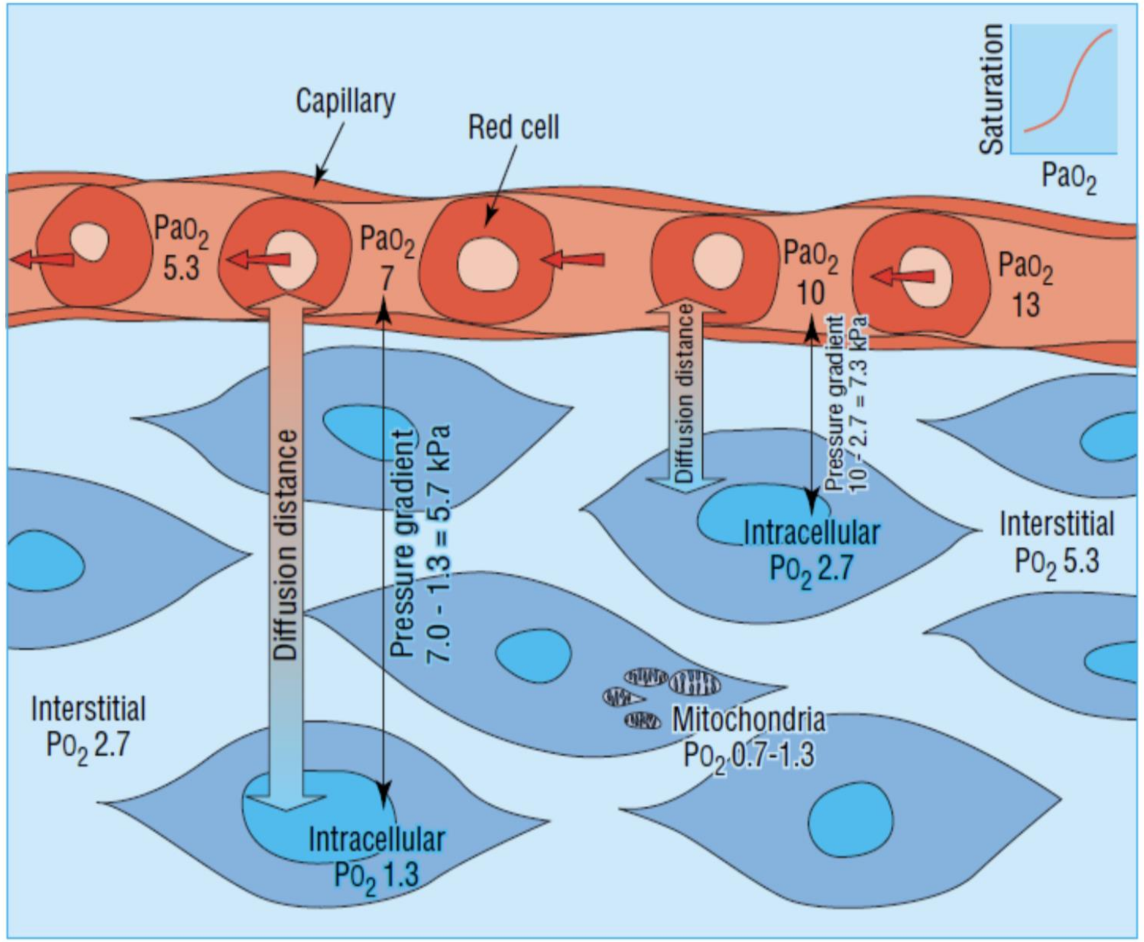
- (p02 INS)=FI02 x pB

- (p02 ALV) < (p02 INS): added water vapor and the balance between 02 removal by pulmonary capillaries and 02 replacement by alveolar ventilation.

Oxygen cascade from lung to tissue



But it doesn't end there



- Oxygen Content and Hemoglobin
- -Ca02/Cv02
- -Aggregate of 02 bound to Hb(98.5%)
- mL/dL
- Primary determinant of 02 content:Hb concentration
- 1g Hb-binds 1.34 ml 02
- 0.003ml/dL: solubility coefficient of oxygen in plasma

Arterial and Venous Oxygen Content

- Equation 1
- Ca02=(1.34 x Hb x 02 Sat) + (Pa02 x 0.003);   Hb-15 Sat 100% P02 90
- -Ca02=20g/dL

- Cv02=(1.34 x Hb x 02Sat) + (Pv02 x 0.003);   Hb-15 Sat-75% P02-40
- -Cv02=15g/dL

Oxygen Delivery and Oxygen Consumption

- Equation 2
- D02=CO x Ca02 x 10=5L/mn x 20mL x 10=1000mL/mn

- Equation 3
- V02=CO x (Ca02-Cv02)x 10= 5L/mn (20-15)mL/dL x 10=250mL/mn

- -D02/V02=5:1-4:1 OR OER(V02/D02)=20%-25%
- -Oxygen Extraction Ratio=20-25%

- B-Co2 transfer:1-dissolved in plasma(10%); bound to Hb(30%); carried as bicarbonate(60%)

- PaC02=40mmHg   PV02=46mmHg

- Ambient air PC02=0.3mmHg

- Equation 4
- Respiratory Exchange Ratio:VC02/V02

MEMBRANE GAS EXCHANGE PHYSICS AND PHYSIOLOGY

OXYGEN CONTENT,DELIVERY AND CONSUMPTION

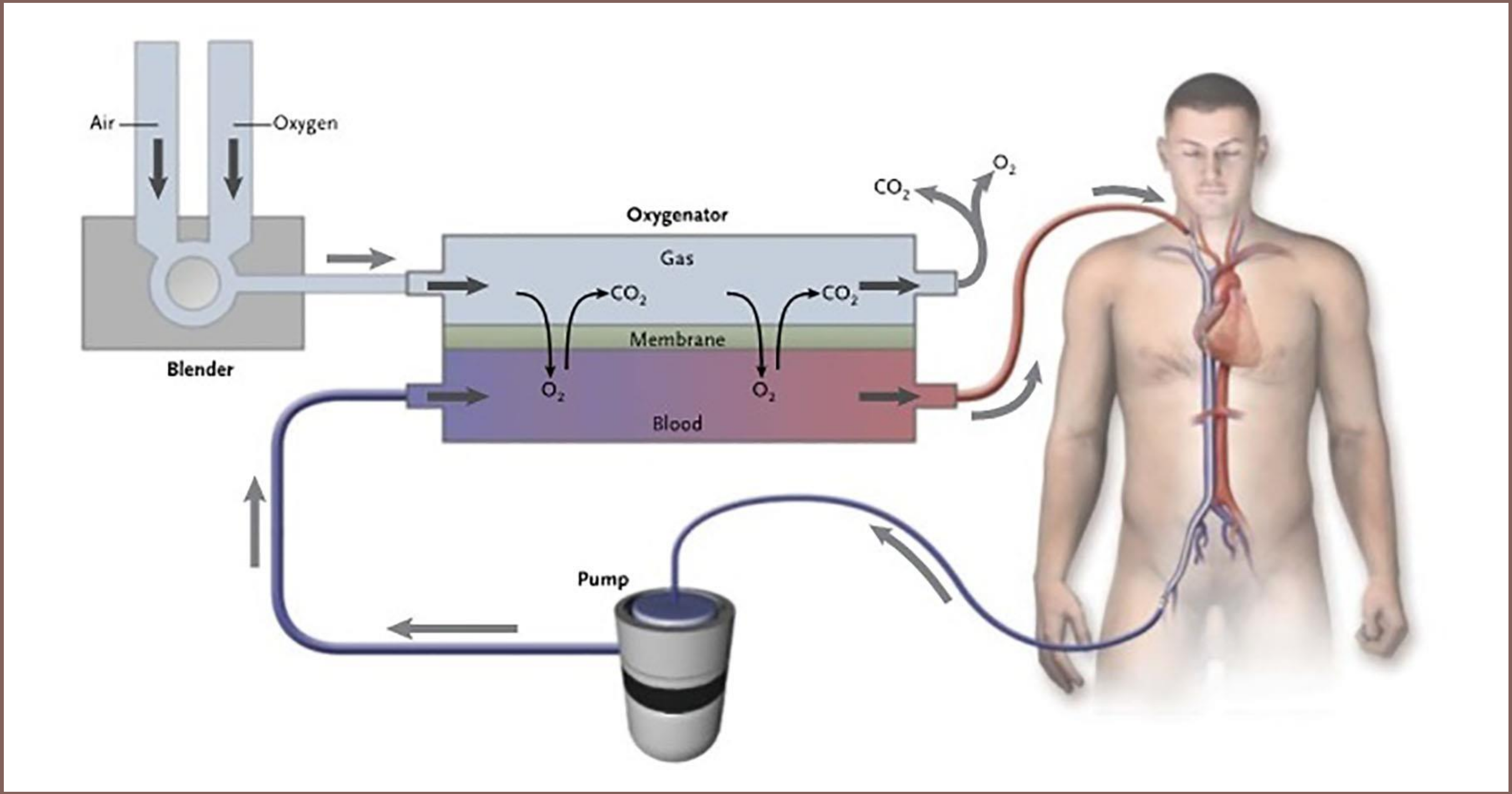
Membrane Gas Exchange Physics and Physiology

- Gas Exchange Devices(GED):
- Gas exchange by perfusing venous blood through a network of thousands of small hollow fibers
- The tubes are filled with continuously flowing gas(SGF) while blood flows exterior to the fibers
- -Add 02 and remove C02
- P02=40mmHg; PC02=45mmHg
- -Rated Flow:The blood flow rate at which venous blood with saturation of 75% and Hb of 12gm/dL will exit the GED with a saturation of 95%

Membrane Gas Exchange Oxygen Delivery

- 02 Delivery
- -Max 02 delivery of a GED: amount of 02 delivered per minute when running at rated flow
- -Difference between outlet-inlet blood=4-5cc/dL

- -Ex: 1-rated flow of 2.0L/mn:max 02 delivery
- -2.0L/mn(20dL/mn) x 5cc/dL=100cc/mn
- 2-4L/mn=200cc/mn

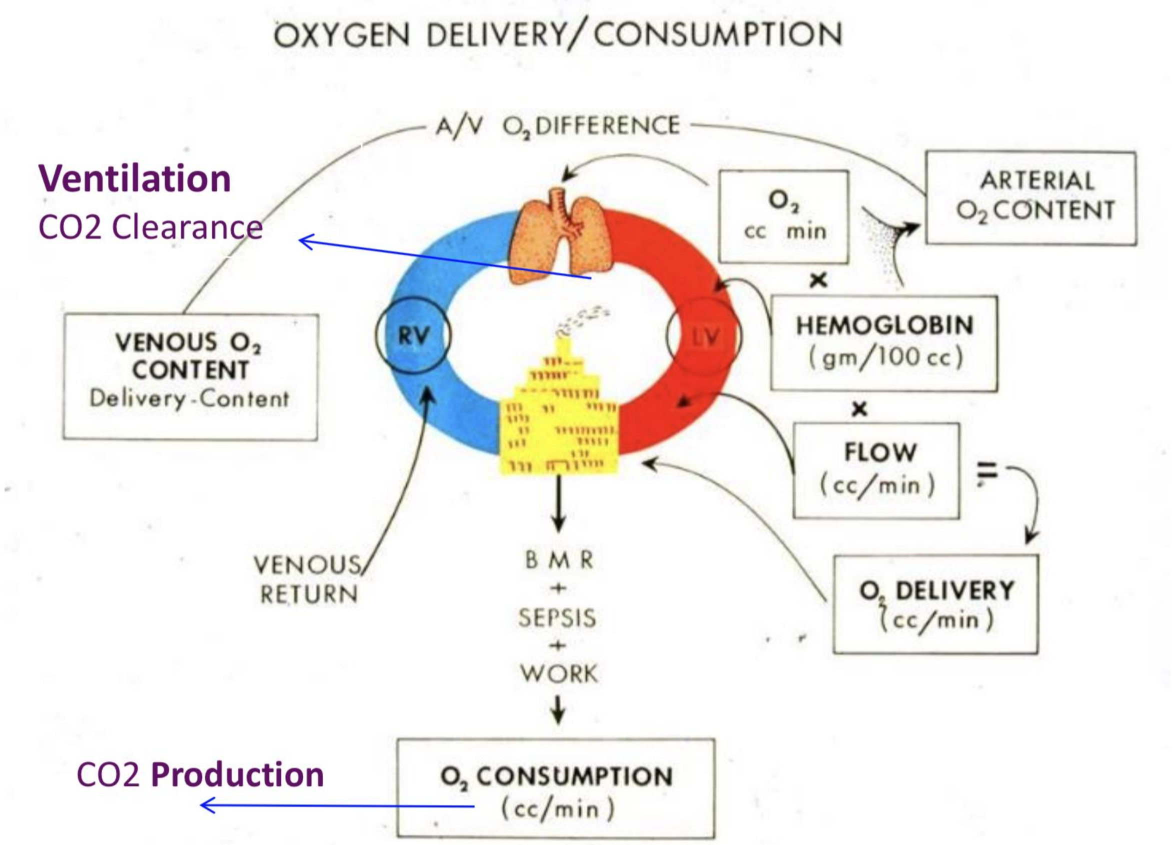


Air
Oxygen
Blender
Oxygenator
Gas
CO_2
CO_2
Membrane
O_2
O_2
Blood
CO_2
O_2
Pump

Oxygen Content,Delivery and Consumption -Membrane Gas

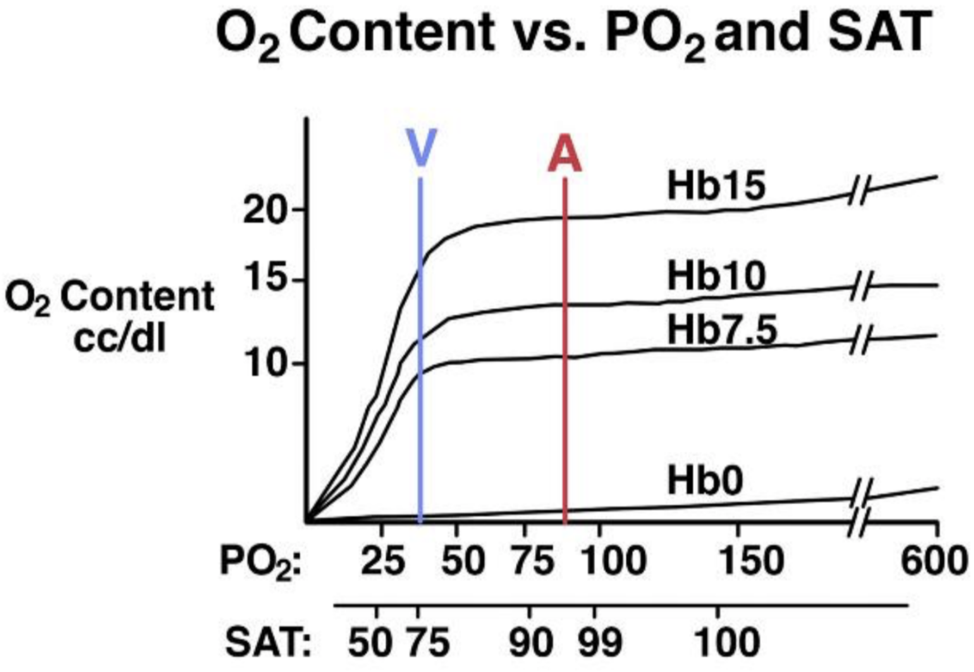
- Ca02(cc/dL)=1.34xHb(gm/dL) x sat + P02(mmHg)x0.003cc/dL/mmHg
- Cv02=1.34x Hb x sat + P02 x 0.003cc/dL
- D02(cc/mn)=C02(cc/dL) x CO(L/mn) x 10
- V02=(Ca02-Cv02) x CO x 10
- D02/V02-5:1 OR OER(V02/D02)-20% ; lowest tolerated: 2:1 OR 50%

Critical Care Physiology

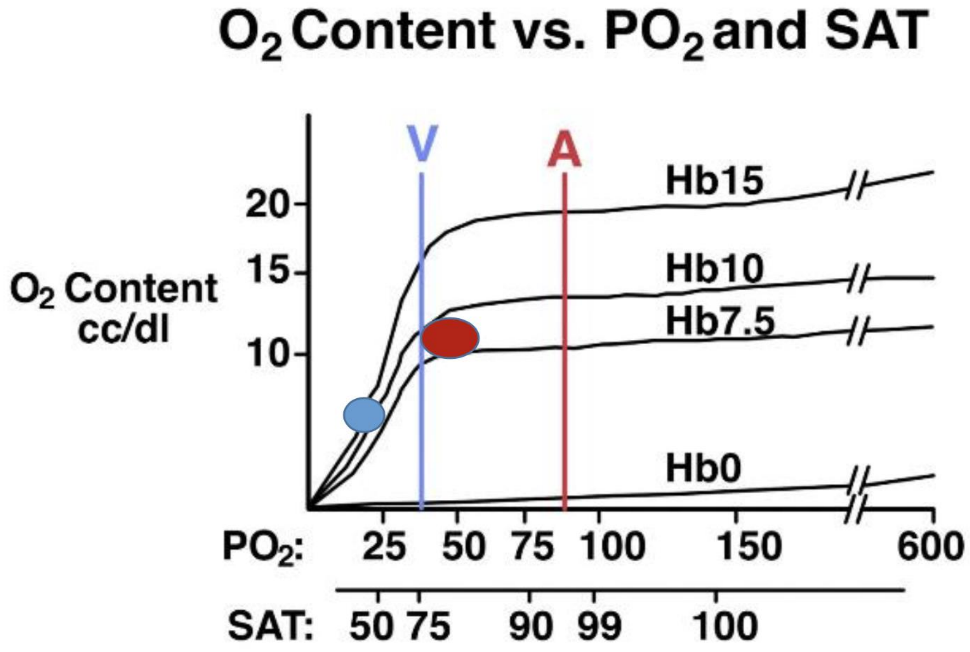


Normal DO2/VO2 = 5:1. DO2/VO2 below 2:1 = shock

Oxygen in blood



Oxygen in blood



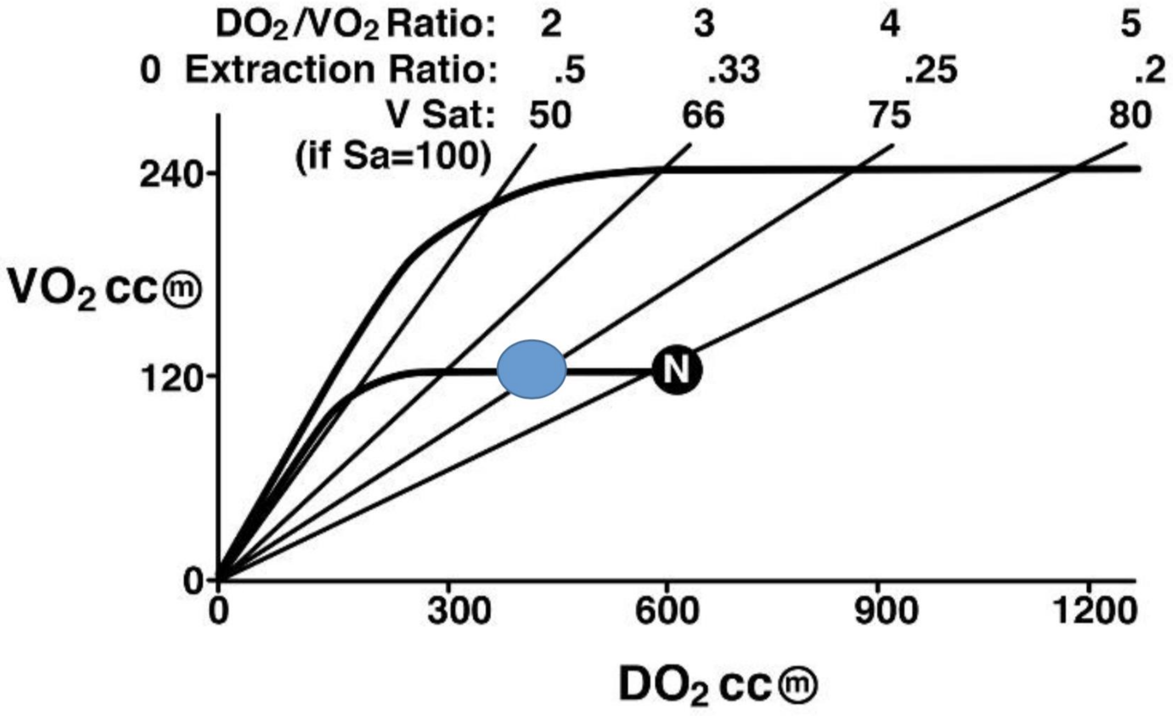
Arterial C O2=11.7 cc/dL

Venous C O2= 5.36 cc/dL

AV DO2 = 6.34 cc/dL

Oxygen content = Hb gm/dL x % sat x 1.34cc/gm = ccO2/dL

OXYGEN CONSUMPTION/DELIVERY AND SHOCK



Membrane Gas Exchange C02 Removal

- Sweep Gas
- -Gas ventilated through the GED
- -Usually 100% 02
- --When mixing 02 with Room Air—02 /air blender
- --Carbogen gas:5% C02/95% 02)
- --Rate: start 1:1-adjust rate to pC02(36-44mmHg)

Membrane Gas Exchange:C02 Removal

Increasing SGF: decreases C02 but won't affect 02

Water vapor can condense within the gas compartment of the membrane lung and can be cleared by intermittently increasing SGF to higher rate(otherwise ,C02 may Increase)

Membrane gas exchanger: clears C02>adding 02