TOTAL AND PARTIAL LIQUID VENTILATION USING PERFLUOROCARBONS

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Characteristics of Perfluorocarbons

Clear, colourless and odourless
Inert, non toxic, biocompatible
Stored at room temperature and resistant to autoclaving

Insoluble in water or in lipids
Water or lipids do not dissolve in them

Denser than water and soft tissue
Low surface tension and generally low viscosities

Affinities for gases: oxygen, carbon dioxide and many other gases

Metabolism and elimination

Uptake, distribution and elimination are not clearly defined
Spontaneously evaporate from the lung and the skin.
The PFC absorbed can remain in the tissues for long periods but does not seem to exert any toxic effects.

Properties of selected PFCs compared with water below.

	Water	Rimar 101*	Perflubron**	FC77***
Boiling point (°C)	100	101	143	97
Density at 25°C (g/ml)	1.00	1.77	1.93	1.75
Kinematic Viscosity (centistokes at 25°C)	1.00	0.82	1.10	0.66
Vapour pressure (mm Hg at 37°C)	47	64	11	75
Surface tension	72	15	18	14
O_2 solubility at 37°C (ml gas/ 100 ml liquid)	3	52	53	56
CO_2 solubility at 37°C (ml gas / 100 ml liquid)	57	160	210	198

* Rimar 101 from Mitsubishi, Milano, Italy
** Perfluoroctylbromide (Perflubron) from Alliance Pharm, Corporation, San Diego, California, USA.
*** FC77 from 3M Corporation, St. Paul, Minnesota, USA.

Development of liquid ventilation

Total body immersion
Bronchoalveolar lavage
Liquid ventilation by gravity

Total Liquid Ventilation (TLV)

PFCs instead of gas to obtain gas exchange

Equipment

- Pump
- membrane oxygenator
- CO_2 removal

Methodology

1st phase
Short period of partial liquid ventilation
Lungs gradually filled with warmed oxygenated PFC
30 ml/kg of PFC is introduced and further quantities added until the lung has been completely filled

2nd phase
Connection to the ventilator
Tidal volume: 15-20 ml/kg
Respiratory rate: 4-5 breaths/min

Maximum inspiratory peak pressure is 30 cm H_2O(15 - 20 cm H_2O is sufficient)
Negative pressure during expiratory phase ranges from $^{-}$15 to $^{-}$30 cm H_2O

3rd phase
Return to conventional artificial ventilation
Disconnection from artificial ventilation when PFC has evaporated from the lung

Partial Liquid Ventilation (PLV)
PFCs to fill the functional residual capacity (FRC) of the lungs whilst gas tidal volumes are delivered by a conventional volume-regulated ventilator

Methodology

1st phase
30 ml/kg of PFC is introduced in order to partially or fully replace FRC
10 ml/kg of PFC is added every hour to replace redistribution or evaporative losses

2nd phase
Disconnection from artificial ventilation when PFC has evaporated from the lung

Side effects
Do not return to baseline of PaO_2 in healthy lung

Decreased periferal perfusion

Persistent lactic acidosis with hyperlactatemia and decreased peripheral perfusion
Lung barotrauma
Respiratory tract deformation

Indications for liquid ventilation
Respiratory Distress Syndrome (RDS) in premature babies
Adult Respiratory Distress Syndrome (ARDS)

PLV ARDS trial results

Bronchoalveolar lavage
- Removal of material present in the lungs
- Improve gas exchange
- Reduce tendency to atelectasis
- Prevent loss of surface activity
- Elimination of dishomogeneous lung ventilation

Indication of Bronchoalveolar lavage Meconium aspiration syndrome
- Inhalation syndrome from different origins
- Cystic fibrosis and proteinosis

Topical administration of drugs
- Antibiotic
- Chemotherapy

Cancer
- Heating pulmonary lobi
- Increase lobar or lung haematic flow
- Increase effect of radiotherapy and chemotherapy

Problems to be solved:
- More knowledge of uptake and metabolism of PFC
- Safety of liquid ventilation over a long treatment
- Optimal duration of therapy
- Return to conventional gas ventilation