اجهزة التخدير النظري المرحله الثانيه

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Physical principles
part 2

PRESSURE

Pressure is the force exerted per unit of area

P = F/A

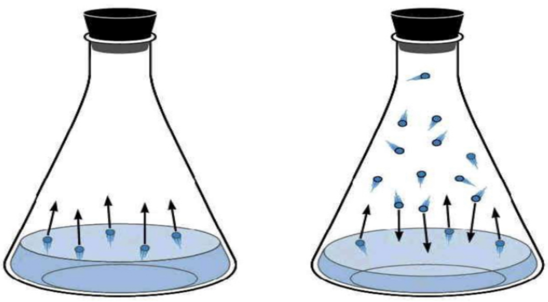
1Bar= 1Atm =100kPa =760mmHg =760torr =14.7psi =1000cm water

Absolute pressure in cylinder= Gauge pressure+ Atmospheric pressure

Vapor Pressure: the pressure exerted by vapor on the wall of its container

saturated vapor pressure (SVP) :

is the pressure exerted by a vapor in equilibrium with its liquid at a given temperature.



Critical Temperature

Temperature above which a gas cannot be liquefied, No matter how much pressure is applied.

N_2O 36.5 °C,
O_2 - 119°C
CO_2, 31.1°0

The Behavior of Fluids and gases
The flow of gases or liquids can be one of **two types**:
laminar or turbulent.
In laminar flow, the fluid flows steadily in one direction.
in turbulent flow, it swirls in eddies.
Turbulent flow is characterized by random movement of the gas molecules down the air pas-sages (it swirls in eddies).Turbulence generally occurs at high gas flows, at sharp angles or branching points.

The probability of turbulent rather than laminar flow occurring in a tube can be determined by calculating an index known as the **Reynolds number:**
Reynolds number = $v\rho d / \eta$
v = Linear Velocity of fluid
p = Density of fluid
d = Diameter of tube
η = Viscosity of fluid

If the Reynolds number exceeds 2000, turbulent flow is likely to be present; if the Reynolds number is below 2000, the flow is likely to be laminar.
flow= pressure drop × $\pi r^4 / 8\eta l$

HEGAN- POISSUILLES' LAW
FOR LAMINAR FLOW

$F = \pi r^4 (P1 - P2) / 8\eta l$

a viscous fluid which moves with laminar flow through a cylindrical conduit of radius r and length L, the volume flow rate F is directly proportional to the pressure difference AP between the two ends of the conduit and to the fourth power of its radius, and inversely proportional to the viscosity n of the fluid and to the length of the conduit"

resistance : 8 X Length X Gas viscosity / π X (Radius)4

This equation tells us that turbulent flow occurs when fluids flow at high velocity, through large diameter tubes and when fluids are relatively dense.

Density is much more important than viscosity when it comes to turbulent flow.

APPLICATION OF REYNOLD'S NUMBER

Use of HELIOX (Helium and Oxygen mixture)

Helium reduces the density of gas inhaled

Hence makes flow more laminar and reducing resistance.

Effect of density on the onset of turbulent flow is the use of helium in respiratory disorders.

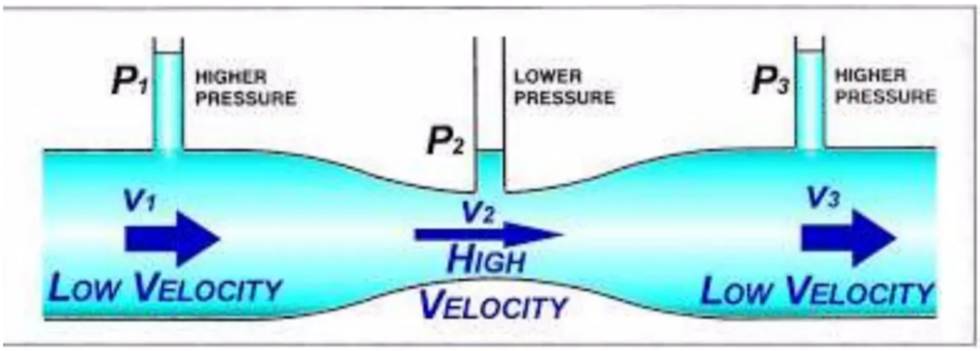
Hence using HELIOX will decrease the resistance and increase the flow.

Bernoulli’s Law, the Bernoulli Effect, and the Venturi

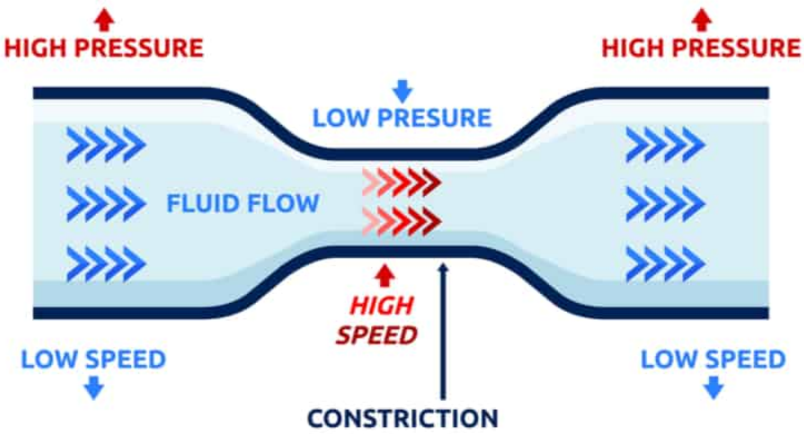
In anaesthesia, Bernoulli’s Law, the Bernoulli Effect, and the Venturi effect are important concepts related to fluid dynamics and gas flow, particularly in the context of gas delivery systems.

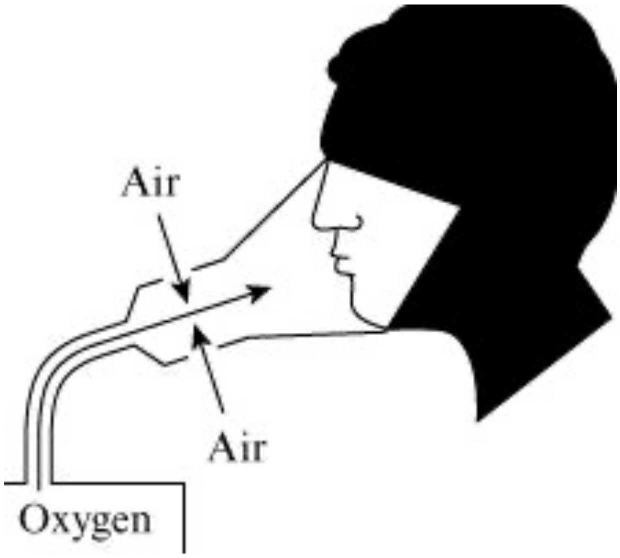
Bernoulli's Law states that in flow, an increase in the speed of the fluid or gas occurs simultaneously with a decrease in pressure. This principle is essential in understanding how gases behave in the respiratory system and in anaesthesia machines.

The Bernoulli Effect refers specifically to the phenomenon where a fluid's velocity increases as it passes through a constricted area , leading to a reduction in pressure in that region. In anaesthesia, this effect can be utilized in devices like nebulizers and vaporizers, where the rapid airflow creates a vacuum that draws liquid medication into the stream, converting it into an aerosol or vapour.



Venturi effect is a specific application of the Bernoulli Effect, describing how a fluid flowing through a constriction experiences a drop in pressure and an increase in velocity. This principle is used in various





anaesthesia equipment, such as Venturi masks, which create a negative pressure to entrain ambient air and mix it with a controlled oxygen supply. This allows for precise control of oxygen concentrations delivered to patients.

Application in Anaesthesia

- **Vaporizers:** Use the Bernoulli Effect to convert liquid anaesthetic into vapor for inhalation.
- **Nebulizers:** Employ the same principle to aerosolize liquid medication, ensuring effective delivery to the lungs.
- **Venturi Masks:** Utilize the Venturi effect to mix room air with oxygen, allowing for specific oxygen delivery ratios.

SURFACE TENSION

Surface tension forces tend to reduce the area of

$$\text{Pressure} = \frac{2T}{R} = \frac{2\times\text{surface tension}}{\text{Radius}}$$

interface and favour alveolar collapse.

According to Laplace law:

2T=PR

So alveolar collapse is directly proportional to surface tension but inversely proportional to alveolar size.

This means that smaller alveoli, with a smaller radius, experience higher internal pressure due to greater surface tension, which increases the risk of collapse. Surfactant, a substance produced by the alveolar cells, reduces surface tension, helping to maintain the stability of the alveoli and prevent their collapse during exhalation.

The surface tension of the alveoli is reduced by the surfactant which is secreted by type II pneumocyte .Ability of surfactant to lower surface tension is directly proportional to its concentration within alveolus.