Al-Mustaqbal University College
Department of anesthesia

Lecture of anesthesia equipment

Teaching by

Dr. Noor Salah Al-kudm

Flow and anesthesia:

Flow is defined as the quantity of a fluid passing a point in unit time.

Quantity = {Q˙} quantity per unit time. Ex: blood flow

*****There is a big difference between flow and pressure

Pressure = force/ area. Ex: blood pressure

Why we study flow in anesthesia??????????

We study flow for only gases and liquid

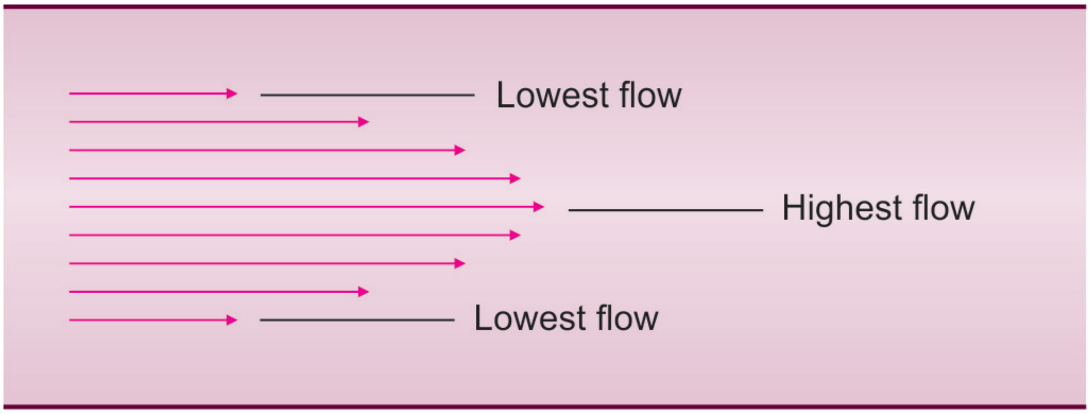
Because flow of the gas and liquid has many application in anesthesia and intensive care unit.

Flow Types:

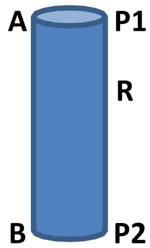
Flow can be described as **laminar** or **turbulent.**

Laminar Flow: In a laminar flow, the molecules of the fluid move in numerous “layers” or laminate.

- It's regular, silent and smooth.
- Depend of viscosity (اللزوجة للسائل)
- **Obeys hagen poiseiulle formula**



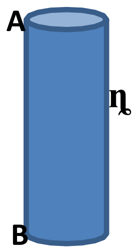
For flow to occur, there must be **pressure difference** between ends of tube. **Flow** across the tube also depends on **diameter** of tube, **length** of tube and **viscosity** of fluid.



**$\dot{Q}=F=\Delta p/R$

R= resistance المقاومة

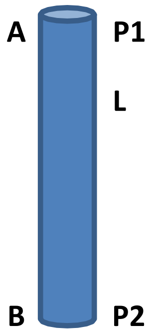
P= pressure الضغط



R is depend on pattern of flow, if its <u>limner</u> or <u>turbulent</u>

During the limner R $\rightarrow$ η

η= viscosity اللزوجة



L= length of the tube طول الانبوب

R $\rightarrow$ L

F=1/L

R $\rightarrow$ 1/d

d = diameter

“Hagen–Poiseuille” equation:- $Q = \pi Pd4/128\ \eta l$

Where, Q = flow, P = pressure across the tube, d = diameter of the tube, η = viscosity, l = length of the tube, π/128 = constant.

Examples: - (clinical application)

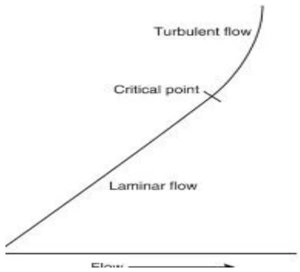
1. Tube diameter: If the diameter of the tube is halved, the flow through it reduces to 1/16. This means that flow is directly proportional to d. That is why fluid flows rapidly through 16 G cannula compared to 22 G. Also small size ETT may cause a tremendous decrease in the flow of gases.

2. Length: If the length is doubled the flow is halved; therefore, flow is inversely proportional to the length of the tube. Therefore, fluid flows slowly through central line compared to peripheral cannula.

3. Viscosity: This is a measure of the frictional forces acting between the layers of the fluid as it flows along the tube. As the viscosity increases the flow decreases proportionally, thus flow and viscosity are inversely proportional. Therefore, it is often seen that increased viscosity increases risk of vascular occlusion.

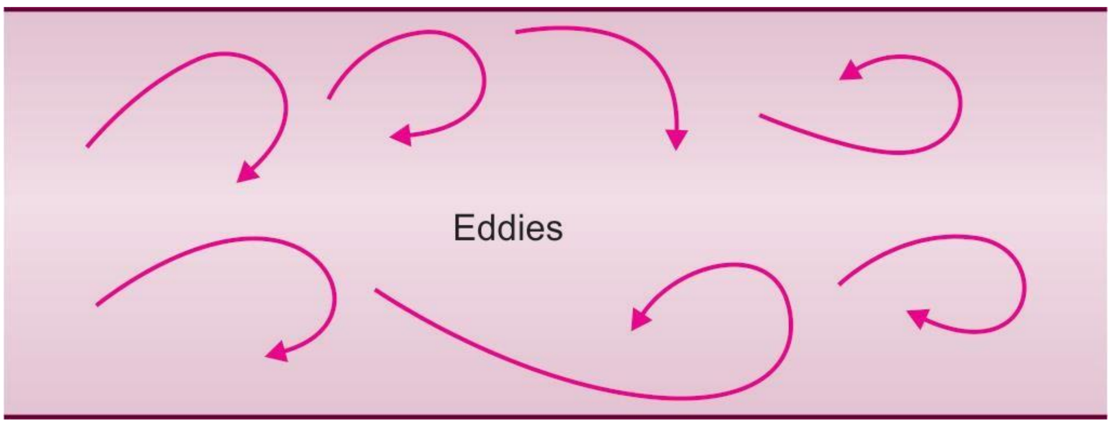
*Laminar flow is generally seen in smooth tubes and at low flow rates.

Limitation ⟶ **critical velocity السرعة الحرجة**



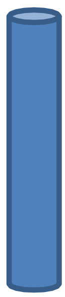
Turbulent Flow:

In a turbulent flow, fluid no longer flows in steady manner. There is formation of eddy currents. This happens when fluid is flowing at a high velocity, in large diameter tubes and when the fluids are relatively dense. In turbulent flow, the flow rate is proportional to the square root of the pressure gradient. This means that to double the flow, the pressure across the tube must be quadrupled.

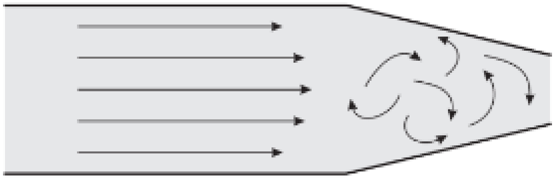


Reynolds Number: Reynolds number tells us about the point at which flow changes from laminar to turbulent.

RN: DVD/V ⟶ 2000



D= diameter	D= density
V= velocity	V= viscosity



If Reynolds number is less than 2,000, flow is laminar. If Reynolds number is more than 2,000, flow is turbulent.

Clinical practice:

In the upper respiratory tract there is often turbulent flow at high flow rates in the trachea, with flow gradually becoming laminar as branching of airways occurs and airway diameter and flow velocity reduce. In addition an obstruction in the upper respiratory tract causes downstream turbulence; thus the respiratory effort will increase, a lower tidal volume is achieved than when flow is laminar. The extent of turbulent flow may be reduced by reducing gas density; clinically this is sometimes achieved by administration of oxygen-enriched helium rather than oxygen alone (oxygen density— 1.3, helium density—0.16).

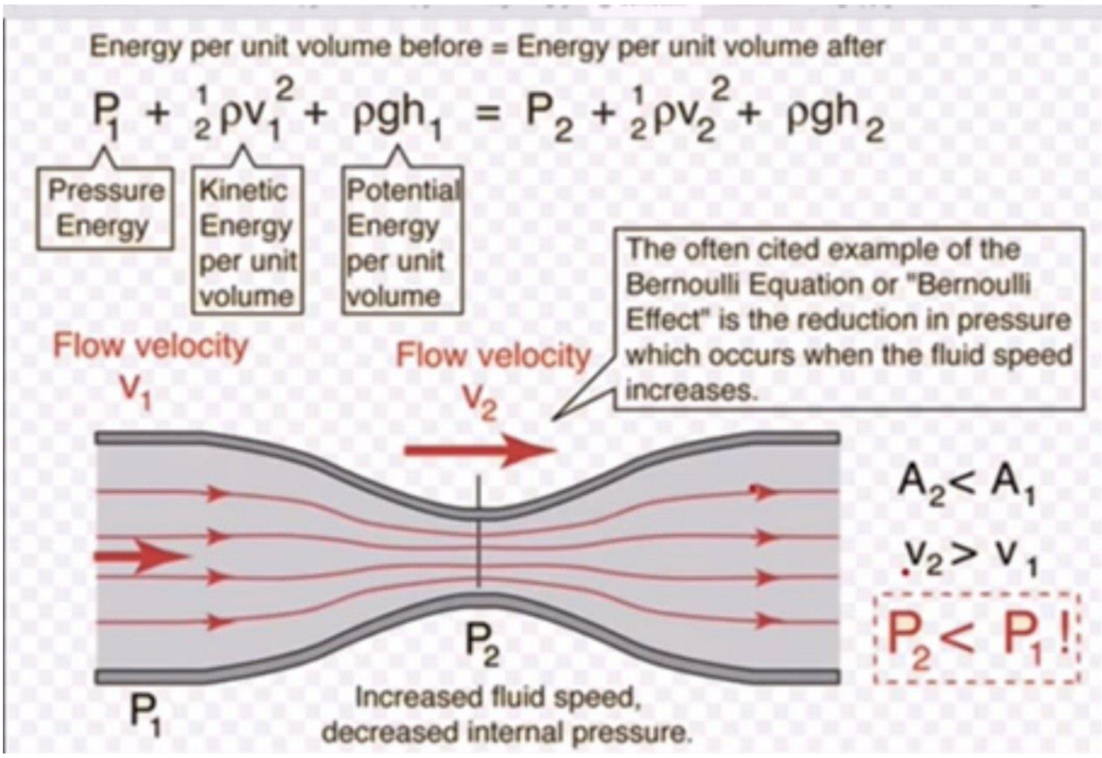
In aesthetic breathing systems a sudden change in diameter of tubing or irregularity of the wall may be responsible for a change from laminar to turbulent flow. Thus tracheal and other breathing tubes should possess smooth internal surfaces, gradual bends and no constrictions. Resistance to breathing is much greater when a tracheal tube of small diameter is used. Tubes should be of as large a diameter and as short as possible.

Bernoulli’s Principle:

Bernoulli’s principle shows that as fluid passes through constriction, there is an increase in velocity of the fluid.

Venturi Effect:

This is the consequence of the Bernoulli’s principle. The pressure drop induced by the increase in velocity of a fluid passing through a narrow orifice can be used to entrain air, e.g. Venturi masks, nebulizers and suction apparatus.



Energy per unit volume before = Energy per unit volume after
$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$
Pressure Energy
Kinetic Energy per unit volume
Potential Energy per unit volume
The often cited example of the Bernoulli Equation or "Bernoulli Effect" is the reduction in pressure which occurs when the fluid speed increases.
Flow velocity v_1
Flow velocity v_2
$A_2 < A_1$
$v_2 > v_1$
$P_2 < P_1$!
P_2
P_1
Increased fluid speed, decreased internal pressure.

Thank you