## **Understanding Blood Flow and Blocked Arteries – A Simple Physics-Based Report**

### **1. Blood as a Fluid**

Blood behaves like a **fluid** moving through pipes — in this case, our **arteries**. Under normal conditions in large vessels, blood acts like an **incompressible Newtonian fluid**. That means:

* It doesn’t compress under pressure (like water)
* It flows smoothly and evenly (especially when blood vessels are wide and healthy)

This smooth, straight-line flow is called **laminar flow**. It reduces resistance and allows the heart to pump efficiently.

But when arteries get **blocked or narrowed**, flow becomes disrupted. The smooth flow turns into **turbulent flow**, which:

* Increases resistance to blood movement
* Forces the heart to work harder to push blood through
* Can cause damage to vessel walls and further health problems
* Link : <https://youtu.be/Yh6h-0Ppwdk?feature=shared> ( **Newtonian and non Newtonian fluid )**
* Link : <https://youtu.be/9A-uUG0WR0w?feature=shared> (**laminar flow)**

### **2. Poiseuille’s Law – How Flow Depends on Radius**

This law explains how fluid flows through a tube (or artery). It tells us that **flow rate depends on the pressure, the viscosity of the fluid, and especially the radius of the tube**.

Q = (π ΔP r⁴) / (8 μ L)

Where:

Q = flow rate

ΔP = pressure difference

R = radius of artery

Μ = blood viscosity

L = length of artery

**Key takeaway:** Flow depends on the **fourth power of the radius**. That means:

* A small decrease in artery size causes a **huge drop** in blood flow.
* To compensate, the heart increases pressure — which stresses the heart over time.
* Link : https://youtu.be/UeQu19VChjE?feature=shared

### **3. Bernoulli’s Principle – Pressure and Velocity**

Bernoulli’s principle says that in flowing fluids, **as velocity increases, pressure decreases**, and vice versa.

P + (1/2)ρv² + ρgh = constant

When an artery **narrows** due to a blockage:

* The blood speeds up at the narrow point
* The **pressure drops** in that area
* Downstream areas might not get enough pressure to supply tissues with blood
* This can lead to **ischemia**, where tissues (including heart muscle) don't get enough oxygen
* Link : https://youtu.be/eKEorBipbO8?feature=shared

### **4. Pressure-Flow Relationship**

This relationship shows how **flow depends on pressure and resistance**:

Q = ΔP / R

Where:

Q = flow rate

ΔP = pressure difference

R = resistance

As **resistance increases** (from narrowed arteries), the heart must pump harder to maintain blood flow. Over time, this can cause:

* **High blood pressure**
* **Thickening of the heart muscle**
* Eventually, **heart failure**
* Link : <https://youtu.be/CVIemNoOqtY?feature=shared>

### **5. Waveform Analysis – What the Flow Looks Like**

When doctors use tools like **Doppler ultrasound**, they see waveforms — graphs showing how blood moves over time.

In **healthy arteries**:

* The waveform is **smooth and regular**
* It shows a strong peak when the heart contracts (systole), and a clear second wave when it relaxes (diastole)

In **blocked arteries**:

* The waveform changes:
  + **Very sharp, narrow peaks** at the blockage (fast flow)
  + **Turbulence** just past the blockage (irregular flow)
  + **Weakened signals** beyond the blockage (reduced flow)

Doctors use these changes to **identify blockages** and **judge how serious they are**.

Link : <https://youtu.be/UbwdbK2inZY?feature=shared> (waveform analysis)

## **Conclusion**

Physics plays a big role in understanding how blood flows and how **blocked arteries** affect the **heart**. Key ideas include:

* Blood normally flows smoothly like a Newtonian fluid
* Small changes in artery size cause big drops in flow (Poiseuille’s Law)
* Narrowing increases speed but lowers pressure (Bernoulli’s Principle)
* Resistance increases, forcing the heart to work harder
* Waveform analysis helps spot where the flow changes