

Title: Hagen-Poiseuille's law- "FACT or FICTION"

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ABSTRACT BODY:

Introduction-- The Hagen-Poiseuille's law is fundamental to the understanding of flow principles for Anesthesia trainees. It highlights the crucial importance of a large bore cannula by explaining how the flow increases by 16 times or the fourth power when the diameter of a cannula is doubled.

$$\text{Flow} = \frac{\pi Pr^4}{8l}$$

This however has never been validated in a clinical situation or ever tested in relation to its applicability to humans. A formula derived by a Physiologist and an Engineer about 200 years ago has been blindly transferred to clinical practice.

Methods- I tested the **Hagen-Poiseuille's law** in a clinical setting by making an IV drip and measuring the volume of Normal saline that flowed through a 1mm diameter cannula and repeated the same with a 2 mm diameter cannula. As per the law if all other variables were constant (pressure, length, viscosity) then the flow should increase by 16 times when the diameter is doubled. The increase in flow was noted to be just 6 times more. The same experiment was repeated again with almost identical results. I then removed the IV tubing completely and attached the cannulae to the fluid bag directly. The results however were very similar.

I have since repeated the experiment in a more controlled laboratory environment and the results have again been very similar to an increase of just 6-7 times when the diameter is doubled.

Results – The 1mm cannula had a flow of 48-52ml/min. The 2mm cannula had a flow of about 300-310ml/min. The increase was about 6 times. The two cannulae were of the same length. The pressure in the IV fluid bag was the same and the viscosity was the same. The flow per minute is in fact the same as that is printed on the packaging of these cannulae.

Discussion - The Hagen-Poiseuille's law is widely quoted law in the understanding of laminar flow. The "fourth power" part is especially used to impress upon the trainees that a wide bore cannula is really crucial. This is quoted in almost every Anesthetic textbook¹ and Pediatric life support manuals in relation to massively decreased airflow during Bronchospasm. There is another criterion to be fulfilled which is not well known, but vital for the flow dynamics. The length of the tube must be at least 500-1000 times more than the diameter before the Hagen-Poiseuille's law is truly applicable². This would mean that for a 1mm cannula it need to be 500mm or 50cm long before laminar flow occurs! These ratios between length and diameter of cannula, endotracheal tubes can never be achieved in the human body. Hence the doubling of cannula size never increases the flow by 16 times. This brings us to the question—

How many other "laws" are we using in clinical practice, which have never been validated?

Refs- 1 Basic Physics and Measurement in Anaesthesia- Kenny & Davis,

2 Personal communication : Prof Peter Carpenter, University of Warwick, UK