# The Use of Flow Equation in Functional Coloproctology: A New Theory in Anorectal Physiology

**Ahmed Farag***

*Professor of General and Colorectal Surgery, Cairo University, Cairo, Egypt*

***Corresponding Author:** Ahmed Farag, Professor of General and Colorectal Surgery, Cairo University, Cairo, Egypt.

Anorectal segment is a physiologically highly integrated segment. The mechanical factors modified by sensory and reflex components are integrated instantaneously in order to initiate normal defecation within few seconds and to maintain continence in a fraction of a second.

This highly integrated nature may be responsible the lack of answers to the enigmatic question concerning how the anal sphincter works. This enigma exists despite the enormous research data which studies different factors in an un-integrated approach.

The use of flow equation for mathematic integration of Anorectal physiology first appeared in the international literature by current author in 1998 aiming at answering the above-mentioned question, which may standardize our approaches to functional Colorectal disorders [1].

## The resistance and flow equation in functional coloproctology

The flow equation called the Hagen-Poisuille law was originally designed to study of flow of Newtonian fluids (e.g. Water), in rigid tubes. Poisuille had used the equation successfully in the study of flow of blood (a non-Newtonian solution) in blood vessels (i.e. biologic tubes) [2,3].

Newtonian fluids had been defined as those fluids who have a constant dynamic viscosity at different rates of flow [3]. The Flow equation for the Newtonian fluids can be used for non-Newtonian Fluids e.g. stools, if their shear stress equals Zero [2,3].

According to Douglas., *et al.* the Hagen-Poisuille law can be used for gases and solids, which behave like a very low viscosity and a very high viscosity fluids respectively [4].

The resistance of the anal canal to flow had been suggested by many authors to be a more important factor in maintaining continence than the ability of the muscles to squeeze around the anal canal. However, trials to measure the anal canal resistance mechanically using probes, catheters, small balloons and obturators were unsuccessful [5-8].

Recently the resistance and flow equations had been applied to the field of functional Coloproctology for a mathematically integrated approach of anorectal manometry and defecography [1]. Recently the resistance and flow equations had been applied to the field of functional Coloproctology for a mathematically integrated approach of anorectal manometry and defecography [8,9].

According to the flow equation constipation can be defined as a low flow state during defecation while Anal Incontinence can be defined as abnormal flow of bowel contents through the anal canal during rest or squeeze.

Flow = Pressure/Resistance.

Accordingly, the recto-anal interaction is a pressure - resistance interaction rather than Pressure - pressure interaction.

The anal canal resistance is directly proportionate to Dynamic viscosity (consistency) of stools and A.C. length and inversely proportionate to (anal canal resistance) [4] where:

$$\text{A.C. Resistance} = \frac{128 \text{ x Dynamic Viscosity x A.C. Length}}{3.14 \text{ x (A.C. Diameter)}^4}$$

The flow equation will be finally as follows:

$$\text{Flow} = \text{intrarectal Pressure X} \frac{3.14 \text{ x (A.C. Diameter)}^4}{128 \text{ x D.V. x A.C. Length}}$$

According to the full blown flow equation 4 primary mechanical factors affect the anal continence and defecation in health and disease namely:

1. Intra-rectal pressure (IRP).
2. Dynamic viscosity of the stools (DV).
3. Anal Canal Length (ACL).
4. Anal Canal Diameter (ACD).

Other mechanical factors are secondary factors operating through one or more of the above mentioned primary factors where: The type of food intake, amount of fluids ingested, rate of gastric evacuation, small and large bowel absorption and motility work through the dynamic viscosity factor, the rate of rectal filling, rectal capacity and rectal compliance work through the factor of intra-rectal pressure, while the pelvic floor muscles, Anal sphincters and pelvic supporting connective tissue and fascia work through the factors of anal canal length and diameter.

Sensory and reflex factors are known to intimately interact with the mechanical factors in order to maintain normal continence.

Both factors work through the flow equation by determining which intra-rectal pressure interact with which anal canal dimensions (Length and Diameter), at any given time.

Sensory factors principally affects Intra-rectal pressure due to delayed sensations.

Reflex factors work mainly by determining which anal canal dimensions (and hence resistance) challenged by intra-rectal pressure during rest or squeeze for incontinent patients or during defecation for constipated patients.

Each of the sensory or reflex factors can be numerically quantitated individually or in conjunction with other factors as will be explained Later.

Like most calculations in the biological systems including the human body such as the Brooks formula for fluid replacement in Burns, and formulas for calculation and correction of fluid and electrolyte balance in shock, the mathematically calculated flow was taken as a flow index rather than an accurate measurement of flow in order to avoid too- much minor corrections on the native equation.

Norm grams representing the flow equation during defecation and continence had been plotted in order to facilitate understanding the flow equation and allocation of individual patients as a rough though rapid substitute for suggested mathematical calculations.

## Bibliography

1. A Farag. "The use of Hgen-Poisuille Law for mathematical integration of anorectal physiologic testing in patients with fecal incontinence and pelvic dyschezia and in normal controls". *European Surgical Research* 30.4 (1998): 279-289.

2. Barnes RW. "The arterial system". In Sabiston DC Jr. (ed): a. Essentials of surgery. London, Saunders (1987): 887-932.

3. Massey BS. "Mechanics of Fluids". London LBS/Chapman & Hall (1989).

4. Douglas JF., *et al.* "Fluid Mechanics". Harlow LBS/Longman (1995).

5. Harris LD and Pope CE II. "Squeeze vs. resistance: An evaluation of the mechanism of sphincter competence". *Journal of Clinical Investigation* 43 (1964): 2272-2278.

6. Harris LD., *et al.* "Determination of yield Pressures: A method of measuring anal sphincter competence". *Gastroenterology* 50.6 (1966): 754-760.

7. Katz LA., *et al.* "Anal sphincter pressure characteristics". *Gastroenterology* 52.3 (1967): 513-518.

8. Liberman W. "Objective measurement of external anal Sphincter tension". *American Journal of Proctology* 15 (1964): 375-381.

9. Farag A. "The use of Flow equation in functional Coloproctology: A new theory in anorectal physiology". *Pelviperineology* 28 (2009): 17-23.