

Nonlinearity in pelvic floor medicine and surgery

PETER PETROS

DSc DS (UWA) PhD (Uppsala) MB BS MD (Sydney) FRCOG (London) FRANZCOG CU, University of New South Wales, St Vincent's Hospital, Sydney Australia

Non-linearity involves a lack of linearity between two related qualities such as input and output. For example, in a linear system, $1+1=2$ always. In a non-linear system, the answer varies depending on inputs may be 1.9 one day; 2.05 another day.

Modern medicine has become increasingly reductionist and linear. Arbitrary cut-offs for definitions are the norm. But this is not how the body works. Everything in nature is related and subject to physical laws. These laws are universally non-linear. Simple systems give rise to complex behaviour which are regulated by non-linear feedback control systems. One faulty component may unleash a major cascade of dysfunctions. This is especially so in the pelvic floor, as described by the Integral Theory (1), figure 1. Nor is this a new concept.

Marcus Aurelius, the Roman Emperor and Stoic philosopher expressed a holistic view of Nature almost 2000 years ago (2).

“Always think of the Universe as one living organism, with a single substance, and a single soul; and observe how all things are submitted to the single perceptivity of this one whole; all are moved by its single impulse, and all play their part in the causation of every event that happens. Remark the intricacy of the skein, and the complexity of the web.”

The pelvic floor is a holistic subsystem of Marcus Aurelius's Universe. Every component, ligaments, muscles, nerves work in a collaborative interactive way regulated by a cortical or subcortical function.

Variation, the Gaussian curve, figure 2, is at the heart of non-linearity of the female pelvic floor as each structure affects the other physical laws differently for each patient.

Power Law of Poisseuille Is a key determinant of non-linearity in the pelvic floor as it is an exponential function. Resistance within a tube is inversely proportional to its length and the radius to the 4th power. The urethra and anus are tubes. When the muscles contract against the ligaments to close or open these tubes, the resistance alters exponentially as does continence and evacuation. Thus even minor laxity in the ligaments can cause major symptoms of incontinence or evacuation difficulties such as urinary retention or obstructive defecation.

Gordon's Law of muscle power These functions, opening and closure, are mediated by striated muscle contraction. A striated muscle contracts only over a limited distance. The contractile force falls exponentially if the muscle becomes lengthened. If the ligaments are loose, the muscle effectively lengthens and some of the contractile force is expended to the loose ligament prior to opening or closing the outlet tube.

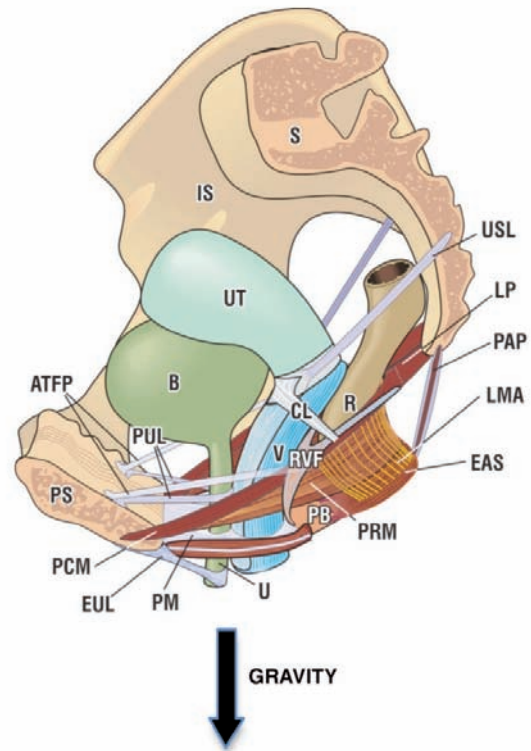


Figure 1. – Functional anatomy of the pelvic floor. Muscles (red) pull against the suspensory ligaments (grey) to support the pelvic organs, bladder 'B', rectum 'R' uterus 'UT', vagina 'V'. The cortex co-ordinates muscle contraction and relaxation to close the urethral ('U') and anal tubes (continence) and to open them (evacuation). Each structure contributes to these functions, differently for every woman. *Ligaments* External urethral 'EUL'; pubourethral 'PUL'; cardinal 'CL'; uterosacral 'USL'; perineal body 'PB'. *Muscles* Pubococcygeus 'PCM'; puborectalis 'PRM'; levator plate 'LP'; conjoint longitudinal muscle of the anus 'LMA'.

Neurological feedback control systems function like an electronic feedback circuit. They are non-linear chaotically determined by peripheral sensors (bladder and rectal stretch receptors) giving afferent signals to the cortex, which reflexly responds to either activate or suppress the micturition or defecation reflexes. These sophisticated feedback systems control vaginal tension opening and closure of the urethra via muscle spindles. Stretch receptors vary in sensitivity. Central control varies. Vaginal tension varies.

It is interesting to examine the basic anatomy of the female pelvic floor through each of these components. The organs, bladder, uterus, rectum are storage containers for urine, the fetus and feces, communicating with the outside via outlet tubes, urethra, vagina and anus. The organs vary widely in size and shape as do the outlet tubes, as per the Gaussian curve with all its standard deviations and statistics

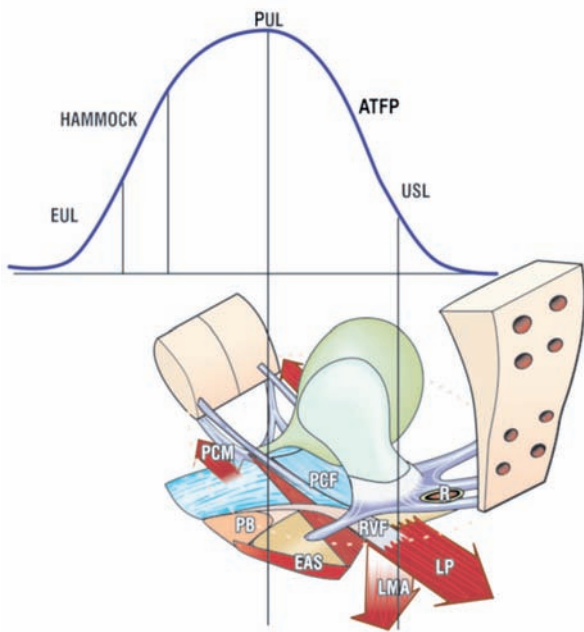


Figure 2. – *The Gaussian Curve*. The contribution of each structure varies with each person and from day to day within that person. Different structures impact synergistically to control bowel and bladder function in the individual patient. The impact of each structure differs between patients. The variance follows a normal distribution curve. This perspective is derived from application of the concepts of non-linearity to the dynamics of the pelvic floor. Labelling as in figure 1.

The ligaments suspend the organs and vary in shape, size, direction and strength.

The muscles contract against the ligaments. The muscle forces act differently, according to the position, standing, sitting, lying. The force of gravity acts differently, according to the position, standing, sitting, lying.

As regards the nerves, sophisticated feedback systems control vaginal tension opening and closure of the urethra. Stretch receptors vary in sensitivity. Central control varies. Vaginal tension varies.

Reductionist thought can be dangerous for the patient. In the 1970's, many infant deaths were caused by premature

intervention purely on the basis of low oestriol results. This is but one tragic example of how grasping “scientific medicine” and ignoring the complexity and non-linearity of biological control mechanisms may lead to wrong management or even disaster.

Homeostasis is a term which has almost disappeared in this era of “scientific medicine”, how the body’s system work together in balance. Yet this concept lies at the core of the “Art of Medicine” as practiced and handed down right from the time of Hippocrates. Older physicians always recognized the concept of non-linearity, how even a small intervention may set off a chain of events in the body which may profoundly disturb this balance. Hence the use of expressions such as “masterly inactivity”, “first do no harm”, “treat the patient then treat the disease”.

The way forward All the pelvic floor mechanisms are non-linear. Understanding this concept is the key to understanding variation in patient symptoms, for example, why a patient may get up to urinate 6 times one night (nocturia) and once or twice another night. Even more important is to understand how repairing one structure, for example pubourethral ligament for urinary stress incontinence may unbalance the other ligaments to cause other symptoms, pain, bladder or bowel. All of this begs the question: do we treat the pelvic floor holistically, and if so, how?

CONFLICTS

None

REFERENCES

1. Petros PE & Ulmsten U. *An Integral Theory of female urinary incontinence*. Acta Obstetrica et Gynecologica Scandinavica, Supplement 153, Vol 69, (1990), 7-31.
2. Translated by George Long <http://classics.mit.edu/Antoninus/meditations.4.four.html> (accessed April 21, 2014).

Correspondence to:

Professor Peter Petros University of New South Wales,
 Professorial Dept of Surgery , St Vincent’s Hospital, Sydney,
pp@kvinno.com