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**P. E. Petros & M. Bush**

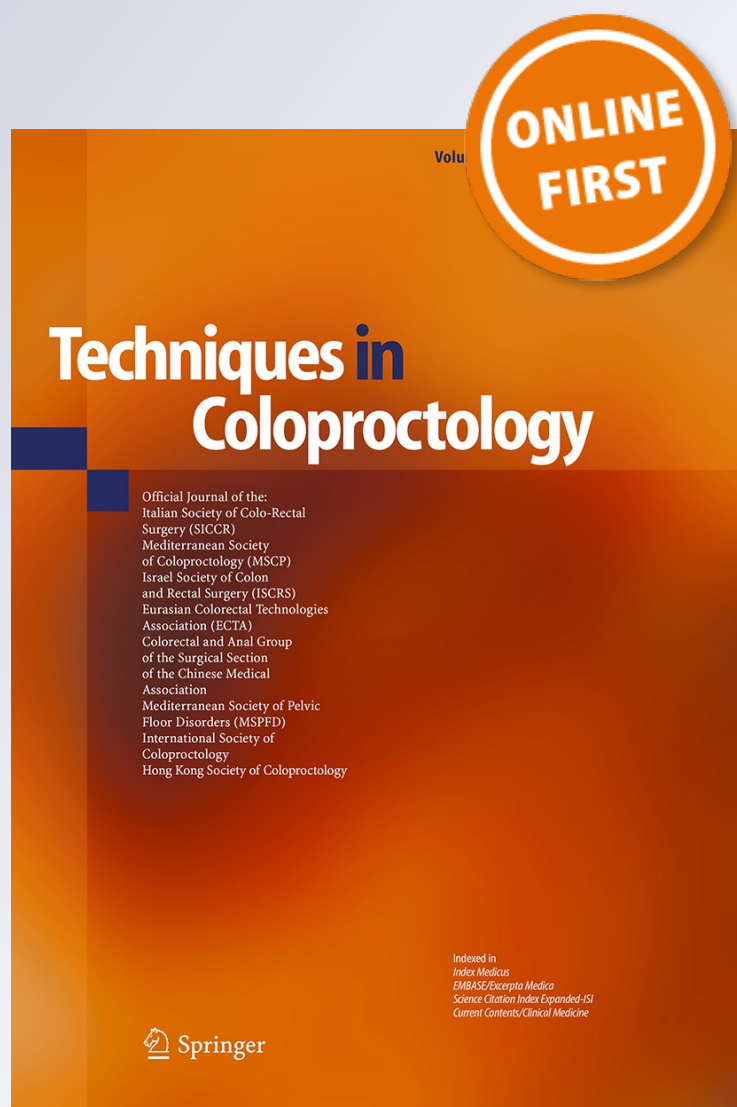
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## Rapid nonlinear bladder and bowel evacuation: an evolutionary survival mechanism?

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Dear Sir,

Complex and chaotic systems are nonlinear, sensitive to initial conditions and the key to understanding bladder function. A system is 'critical' if its phase state changes dramatically with some small input.

Bladder's dynamics has two phases, open and closed (Fig. 1).

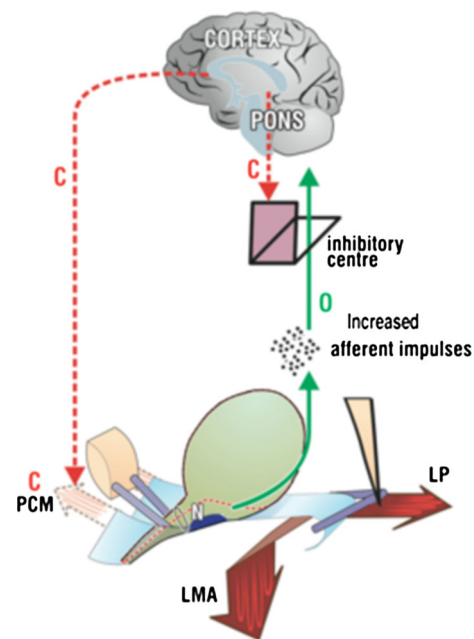
The bladder is always 'en garde', ready to instantly open (evacuate 'O') or close (contenance 'C') depending on circumstance. Criticality is important for rapid phase change. What makes a rapid phase transition possible is:

1. The external striated muscle vectors, LP/LMA arrows (Fig. 1) which can rapidly open or close the urethral tube.
2. The exponential relationship between the radius and the resistance to urine flow (Poiseuille's Law) which exponentially accelerates 1. For example, if the vectors stretching the urethra posteriorly can double the radius of the lumen, this enables micturition by reducing resistance to flow by an order of magnitude [1].

It is this mechanism which makes possible instant commencement of urination and instant stoppage of flow. Rapid evacuation is arguably essential for the survival of

the species. Taking a long time to evacuate would leave the animal vulnerable to attack.

In the normal patient, the peripheral neurological control mechanism consists of a musculo-elastic complex which is controlled by two reflexes which enable or control afferent



**Fig. 1** The bladder is shown in the 'open' (micturition) phase. During micturition, the closure reflex 'C' (shown in red broken lines) is overcome by the opening (micturition) reflex 'O', (shown in green unbroken lines). When 'O' dominates, the inhibitory centre 'trapdoor' opens, PCM relaxes so the urethra can be opened out by LP/LMA. There is loss of support for 'N', so the number of afferent impulses increases rapidly. As urine enters the proximal urethra, it further stimulates micturition [3]. LP m.levator plate, LMA conjoint longitudinal muscle of the anus, PCM anterior part of m.pubococcygeus, N bladder base stretch receptors

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impulses from the stretch receptors 'N' (Fig. 1). The micturition reflex acts as an engine to accelerate opening out of the outflow tract. This is a nonlinear mechanism with precise feedback control.

The normal response to afferent impulses, (Fig. 1), is contraction of PCM, which pulls the hammock forward to stabilize the urethra and support 'N'. However, once activated sufficiently to override the inhibitory centres 'C', the micturition reflex drives the external musculo-elastic opening mechanism 'O' such that PCM relaxes, the urethra is opened out, the bladder contracts and urine is expelled, rapidly.

A similar mechanism based on external opening out of the rectum to exponentially lower internal resistance inversely by the 3rd power of the radius [2], explains the rapid defecation observed in animals such as dogs.

#### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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