Urological Research 6, 113-118 (1978)

Urological Research
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REVIEW

Post-Prostatectomy Incontinence

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Anatomy and Physiology

To facilitate the understanding of post-prostatectomy incontinence a brief survey of the anatomy and physiology of the bladder neck and the posterior urethra is necessary (Fig. 1).

The three detrusor muscular layers can be distinguished only in the region of the bladder neck where the outer layer of bladder muscle joins with the urogenital diaphragm and returns to the bladder neck in the shape of a double spiral forming the outer urethral muscular layer. The middle detrusor layer ends at the bladder neck in the shape of a plate which consists of bundles of muscle fibres arranged concentrically around the bladder outlet. The inner layer extends beyond the bladder neck, continuing as an inner longitudinal layer of urethral muscle and gains attachment to the verumontanum. The smooth-muscled layers of autonomically innervated urethral muscles form the so-called internal urethral sphincter.

The striated external urethral sphincter consists of two sections. One part is a true sphincteric muscle which encircles the membranous urethra and is embedded in the urogenital diphragm. The other part consists of bundles of vertical muscle fibres passing up towards the bladder neck and enveloping the distal section of the posterior urethra like a cloak.

These striated muscle fibres come into contact with the smooth muscle fibres of the outer circular layer of urethral muscles by means of extremely fine connections, seen histologically as ligamentous zones of collagenous connective tissue (Fig. 1). Bundles of smooth and striated muscle fibres form part of the prostatic capsule. The prostate is embedded between the outer spiral-shaped urethral muscular layer and the inner longitudinal urethral muscle fibres.

The bladder neck is autonomically innervated and is primarily influenced by the alpha-adrenergic receptors. It closes as a result of stimulation of the alpha receptors and opens when these are blocked. The posterior urethra is also autonomically innervated with both alpha and beta sympathetic receptors and parasympathetic fibres. The striated external sphincter is subject to somatic innervation but may be influenced very slightly by the autonomic system (Fig. 2), which may assist its opening (7).

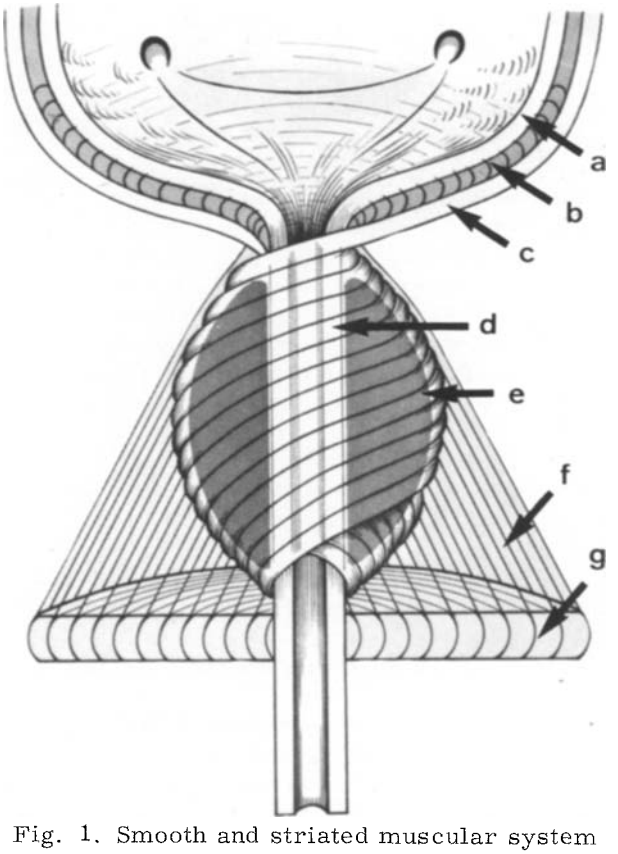

Fig. 1. Smooth and striated muscular system of the bladder neck and posterior urethra:
a) inner - b) middle - c) outer detrusor muscular layers
d) inner longitudinal - e) outer circular urethral muscular layers
f) fibres rising vertically - g) circular fibres of the external sphincter

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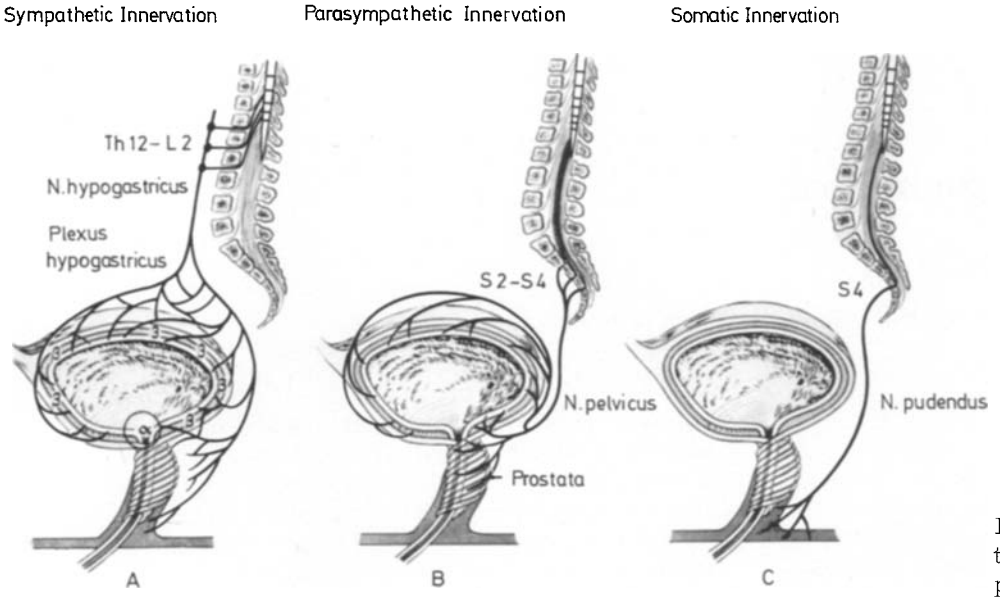

Fig. 2. Schematic representation of the motor innervation of the bladder, posterior urethra and pelvic floor

Which Structures are Responsible for Continence?

The detrusor and bladder neck will not be discussed further in relation to continence since the posterior urethra is the principal structure responsible for continence after prostatectomy.

Strangely enough, the opinion first advanced by Henle (15) as early as 1866 has survived to this day and still enjoys world-wide popularity, namely that the external sphincter is primarily responsible for continence. There are several reasons which make this theory untenable:

1. The external sphincter is a striated muscle, somatically innervated for its closure function, which tires within a brief space of time (30);

2. Paraplegics with a completely flaccid pelvic floor are not necessarily incontinent (31) while paraplegics with a spastic external sphincter remain continent after its incision (39);

3. In normal subjects incontinence does not occur after surgical incision of the external sphincter (17) or after it has been blocked pharmacologically (8, 21, 22);

4. In approximately 90% of all cases of post-prostatectomy incontinence the external sphincter is intact (5, 10, 11, 16, 41).

A fundamentally correct hypothesis was proposed at the turn of the century (37), namely that the smooth muscle of the posterior urethra, (internal sphincter) is responsible for continence. Parasympathetic innervation can be demonstrated beyond doubt by stimulation of the micturition centre (S. 2-4). However the investigation of sympathetic innervation of the lower urinary tract is more difficult because of its dual effects and because it modulates parasympathetic activity.

Attempts have been made to explain continence as a purely passive process (25, 26, 27, 28, 29). The posterior urethra, having a certain length, a prescribed diameter and an equally prescribed - though never precisely defined - mural tension allegedly serves to guarantee continence and retains the urine in the bladder during the filling phase by virtue of the given, purely mechanical, preconditions. The posterior urethra then opens passively as a result of bladder contraction and the rise in intravesical pressure. These misconceptions were based partly on experiments which were not completely valid (23, 24). Clinical observations indicate that continence does not depend on purely passive processes. If that were the case, minimal prostatic obstruction or change in urethral calibre would result in rapidly increasing residual urine. It would also be impossible to explain why there are patients who present with acute retention of urine while others retain enormous quantities of residual urine without any subjective discomfort. Also, one would except to find a correlation between the size of the prostate and residual urine, which does not exist. Only after El-Badawi and Schenk (6, 7) had supplied histochemical proof of sympathetic innervation of the posterior urethra was attention paid to the possibility of an active mechanism

in the posterior urethra leading to pharmacological investigations (1, 4, 32). Current concepts of the relative contributions of structures which are active in closing the posterior urethra are shown diagrammatically in Figure 3. The passive component derives from the connective tissue which is not sufficient in itself. The smooth muscle under autonomic control is the decisive factor for the closing as well as the opening of the posterior urethra.

Petersen (33) experimented with normal conscious subjects which were curarised and intubated and whose bladders were filled to capacity. He was able to show by electromyography of the external sphincter that all potential discharges cease only when the dose of Succinyl-choline was considerably greater than that required for relaxation of pheripheral musculature; a finding contrary to Lapides' experiments (23, 24). He also observed that all these subjects were also fully continent in a vertial position and that even with a full bladder these patients were not able to pass water on command.

Only after the external sphincter had regained electromyographical activity did the voluntary initiation of micturition become possible. In other words, the external sphincter is important in the first instance for the voluntary initiation of micturition and not for the maintenance of continence. Continence is guaranteed by the autonomically innervated smooth-muscled system represented by the posterior urethra.

What Happens After Prostatectomy?

The prostate lies between the inner and the outer smooth-muscled urethral muscular layers (Fig. 4). During prostatectomy, not only the prostatic adenoma but also the inner muscular layer is removed. Postoperatively, only the outer circular urethral muscular layer which is embedded in the prostatic capsule contributes to continence. This layer of muscle does not form a sphincter in a strict anatomical sense. It is a spiral-shaped layer of muscles rather than a true sphincter. In order to be able to fulfil its function as a closing system this spiral-shaped layer of muscles has to rest in an ideal anatomical position, i.e. on a flat section. The spiral-shaped muscle fibre

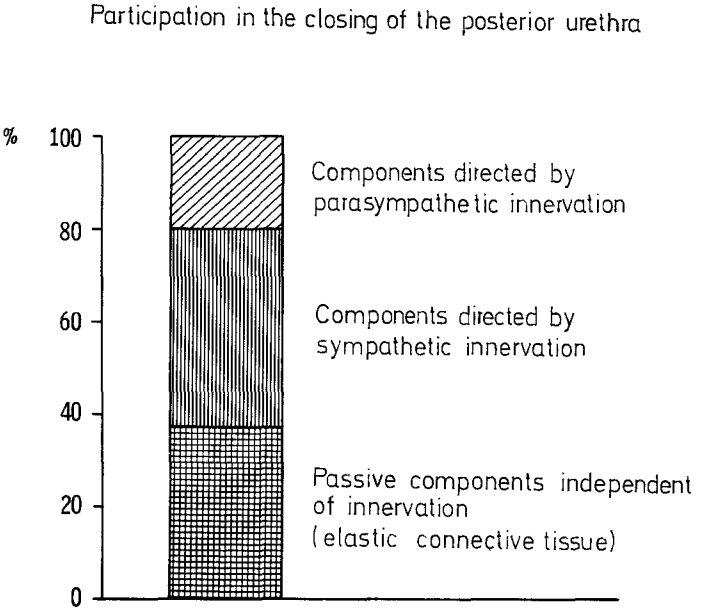

Fig. 3. The components helping with the closing of the posterior urethra (Modefied from Awad (2))

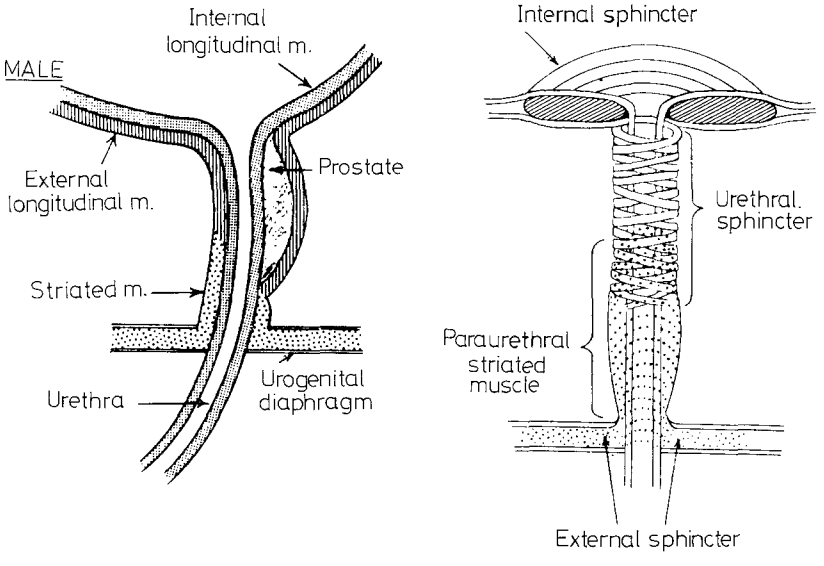

Fig. 4. Position of the prostate in relation to the urethral muscular layers (after Hutch (4))

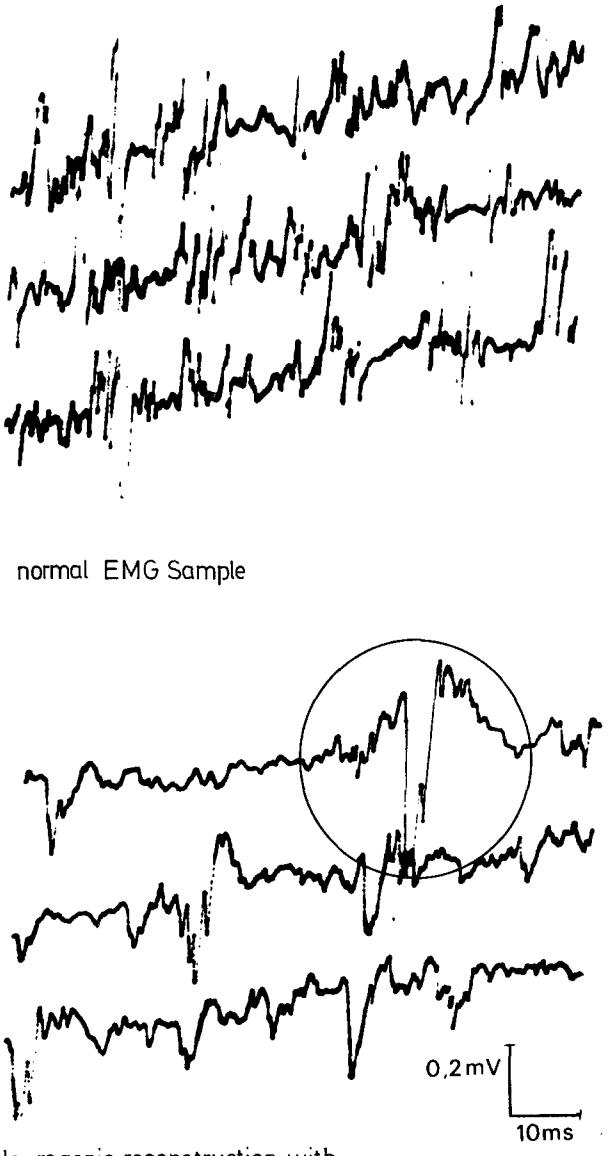

Fig. 5. According to D. Hauri and M. Meyer (14): electromyograms of the external sphincter.
Top: normal EMG
Bottom: pathological EMG post-prostatectomy with incontinence. Particularly conspicuous: lower amplitude, reduced frequencies, broader unit potentials and polyphases as the expression of neural injuries. (Hauri and Meyer (14))

bundles which have lost their shape as a result of prostate growth and prostatectomy and been pushed out of their ideal anatomical position gradually return to a flat position suitable for the maintenance of continence a process which may be assisted by the external sphincter.

This probably explains the very old observation that incontinence after open prostatectomy will gradually disappear in very many cases within a matter of weeks or months while incontinence following transurethral resection remains in most cases. In the first case the smooth-muscled spirals had been simply pushed out of their ideal position and it takes a certain time for them to recover with the assistance of the external sphincter. After transurethral resection not only has the smooth-muscled internal sphincter been injured, but also the extremely fine connections between the striated and smooth-muscled systems have been sharply dissected so that the external sphincter can no longer act on the posterior urethra.

Operative Correction of Incontinence

The sphincteric system, once it has been injured, cannot be repaired again; firstly, because we are not dealing with a single, isolated muscle but with a muscle system which has a complicated anatomical structure and the individual muscles of which do not always function in the same way physiologically; secondly, regeneration of muscle tissue is poor and of no use for continence purposes; furthermore, scars in the connective tissue have no urodynamic value and neural injuries often occur in addition to the other factors.

Prostheses of synthetic material for post-prostatectomy incontinence carry the risk of rejection of foreign material (3, 38, 40), and all present models close the bladder neck or urethra by external pressure so that pressure necroses and erosions may occur (9, 20, 34, 36). The use of the patient's own tissue would be the ideal solution by far. A newly developed operation for incontinence was designed to fulfil two requirements: to create a rigid support for the bladder, and provide a new elastic form of peripheral resistance (12, 13). Radiological and urodynamic studies showed that these objectives were achieved. Analysis of the failures indicated that a successful result could be guaranteed provided the external sphincter was intact which applies in approximately 90 % of all post-prostatectomy incontinence cases. In those cases - and they were relatively rare - where the external sphincter is also injured (Fig. 5) this type of operation does not yield satisfactory results. It could be argued that in reality the results of this operation are no different from, for example, those of Kaufman (18, 19), Puigvert (35) and a number of others and that these authors had merely failed to check the

function of the external sphincter and that therefore their failure rate simply reflects the number of damaged external sphincters. This is not correct for two reasons: 1. the percentage of patients with damaged external sphincters is not as high as the failure rate of these methods; 2. Several of there cases were initially continent but became secondarily incontinent 1 year after the operation.

SUMMARY

- Urinary continence is maintained by the smooth-muscled system of the "internal sphincter".
- The striated external sphincter is not primarily responsible for continence.
- One of the chief functions of the external sphincter is the initiation of voluntary micturition. Its other functions are: random interruption of the urinary stream, reflex control during an increase in intra-abdominal pressure (such as coughing, sneezing, laughing, lifting) complete emptying of the urethra after micturition and stabilization of the posterior urethra in the urogenital diaphragm.
- After prostatectomy an intact external sphincter is important in order to support the smooth-muscled system which continues to be primarily responsible for continence to function as efficiently as possible.
- In approximately 90 % of all postprostatectomy incontinences the external sphincter is intact and this cames a good prognosis following our correcture surgery without the need for prostheses.
- Only in rare post-prostatectomy incontinence cases (approx. 10 %) is the external sphincter also injured. Incontinence surgery according to our method has not been satisfactory in these cases.

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