116

Wallner C[1], Dabhoiwala N[2], DeRuiter M[3], Lamers W[1]
1. Department of Anatomy & Embryology, Academic Medical Center, Amsterdam, The Netherlands, 2. Department of Urology, Academic Medical Center, University of Amsterdam, Amsterdam, The Netherlands, 3. Department of Anatomy & Embryology, Leiden University Medical Center, Leiden, The Netherlands

FUNCTIONAL ASPECTS OF THE PELVIC MUSCLES IN URINARY CONTINENCE

Hypothesis / aims of study

The levator ani muscle is believed to play a crucial role in the maintenance of urinary continence. Women with stress urinary continence often have a weakened pelvic floor (1, 2).
We postulate that a very important anatomical relationship exists between the pelvic floor and the urethral sphincter closure mechanism.

Study design, materials and methods

We studied foetal pelvic sections from the collections of two departments of Anatomy & Embryology. The foetuses (nine females, 10 to 27 weeks of gestation) were stained with haematoxylin and either azophloxine or eosin and/or with azan.
Further, two female foetal pelves (14 & 19 weeks of gestation) were stained immunohistochemically for the presence of striated muscle tissue, using a monoclonal antibody directed against myosin heavy chain and smooth muscle tissue, using a monoclonal antibody directed against smooth muscle actin. Additional sections were stained with haematoxylin-azophloxine as an overview staining and with Gomori's trichrome to stain collagen fibres. After acquiring digital images of the serial sections, three-dimensional reconstructions were prepared using the Amira software package (version 3.0, TGS Template Graphics Software, http://www.tgs.com).

Results

The immunohistochemically stained sections clearly reveal that the external urethral sphincter (EUS) is U-shaped with an opening on the dorsal side (Fig. 1 and 2). The cranial part of the sphincter only surrounds the urethra. The caudal, urethrovaginal part, surrounds the urethra and laterally also a part of the vagina. The EUS has no direct muscular attachment to the bony pelvis but is only connected to the dorsal surface of the pubic bone by connective tissue (Fig 1c).
The EUS has no direct muscular connection to either the levator ani (LAM) or the bulbospongiosus and ischiocavernosus muscles. It is only indirectly connected to these muscles by intervening connective tissue layers. The dorsal border of the urethrovaginal sphincter is attached to the ventral border of the LAM, also through intervening connective tissue only (Fig. 3). Caudally the urethrovaginal component of the sphincter is attached to the bulbospongiosus muscle also by connective tissue.
The internal urethral sphincter (IUS) is constituted from smooth muscle tissue. From immunohistochemical staining for smooth muscle it is evident that the IUS has a completely circular part around the cranial part of the urethra (Fig. 1D, 2F). This is at the same level at which the EUS is U-shaped. The thickest part of the circular smooth muscle sphincter is at the dorsal side of the urethra, where the striated muscle of the EUS is lacking (Fig. 2F).

Interpretation of results

As demonstrated in our study, in female human foetuses the EUS muscle is attached only indirectly to surrounding muscles by intervening connective tissue. This is in total contrast to most other striated voluntary muscles in the body, which require bony fixation points for proper function. Because this sphincter has only soft tissue fixation points composed of connective tissue and striated muscle it is of crucial importance for its proper function that both the connective tissue linkages and the surrounding striated muscles are intact and functioning optimally. If the surrounding tissue looses these functional abilities, the fixation points become destabilised.

Concluding message

The urethral sphincter complex together with its surrounding tissue forms a single dynamic unit of smooth muscle, striated muscle and connective tissue structures. In our opinion, the caudal part of the EUS has an indirect fixation point through the levator ani muscle and its fascia on each side of the pelvis. This fixation point can therefore be effective only if both the levator ani muscle and the intervening connective tissue are undamaged. To our knowledge, this important fact has not been adequately focussed upon previously.

References

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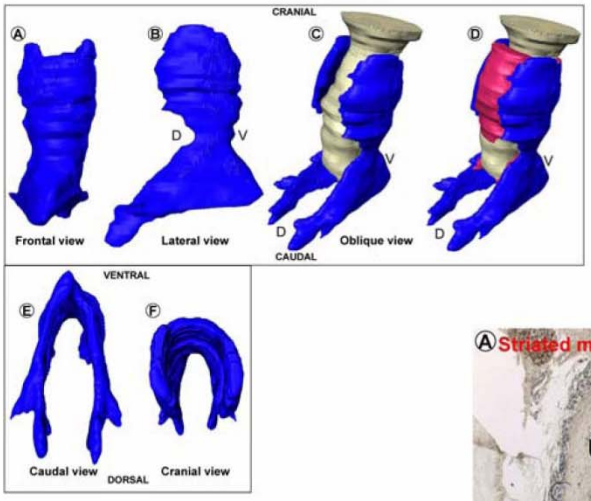

Figure 1. 3D reconstruction of the external (blue) and internal (red) urethral shincter in a female foetus (19 weeks of gestation). **A.** Frontal view. **B.** Right lateral view. **C/D.** Oblique view without (C) and with (D) the internal urethral sphincter. **E.** Caudal view. **F.** Cranial view. The urethra is shown in white in C and D.

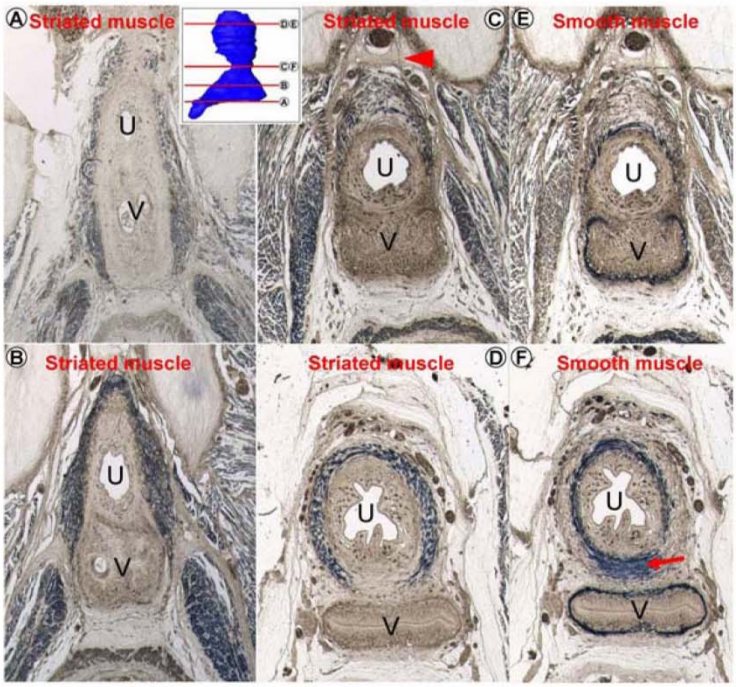

Figure 2. Immunohistochemically stained sections through the external urethral sphincter (EUS) of a female foetus (19 weeks of gestation). **A – D.** Sections from caudal (A) to cranial (D) stained immunohistochemically for striated muscle. Note that the cranial part of the EUS is only connected to the pubic bone by connective tissue (arrowhead in C). **E/F.** Sections stained immunohistochemically for smooth muscle. Note that the thickest part of the internal sphincter is at the dorsal side of the urethra, where the striated muscle of the external sphincter is lacking (arrow in F). U, urethra; V, vagina.

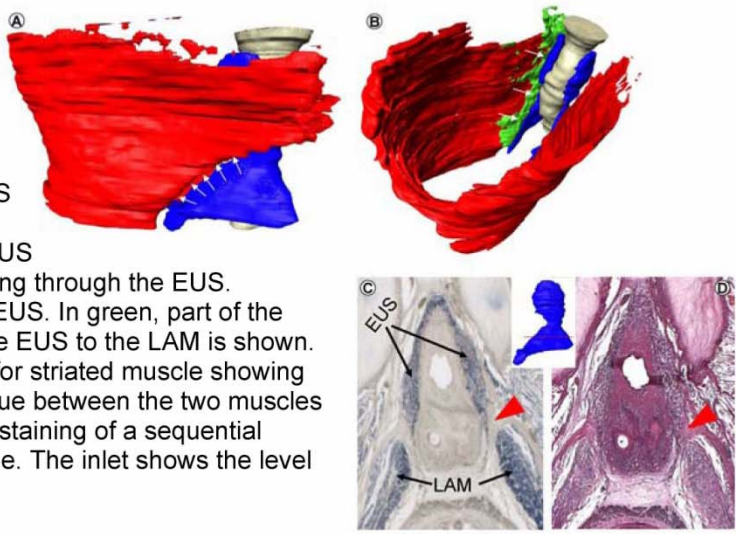

Figure 3. The anatomical relation of the external urethral sphincter (EUS) and the levator ani muscle (LAM). **A.** 3D reconstruction of the LAM (red) and the EUS (blue) of a female foetus (19 wks gest.). The arrows show the close relation of the EUS and the LAM. Note the urethra (white) running through the EUS. **B.** Cranial, oblique view onto the LAM and EUS. In green, part of the intervening connective tissue connecting the EUS to the LAM is shown. **C.** Section stained immunohistochemically for striated muscle showing the EUS and LAM. Note the connective tissue between the two muscles (arrowhead). **D.** Haematoxylin-azophloxine staining of a sequential section clearly showing the connective tissue. The inlet shows the level of the sections through the EUS.

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