

## THE INNERVATION OF THE PELVIC FLOOR MUSCLES: A REAPPRAISAL FOR THE LEVATOR ANI NERVE

### Hypothesis / aims of study

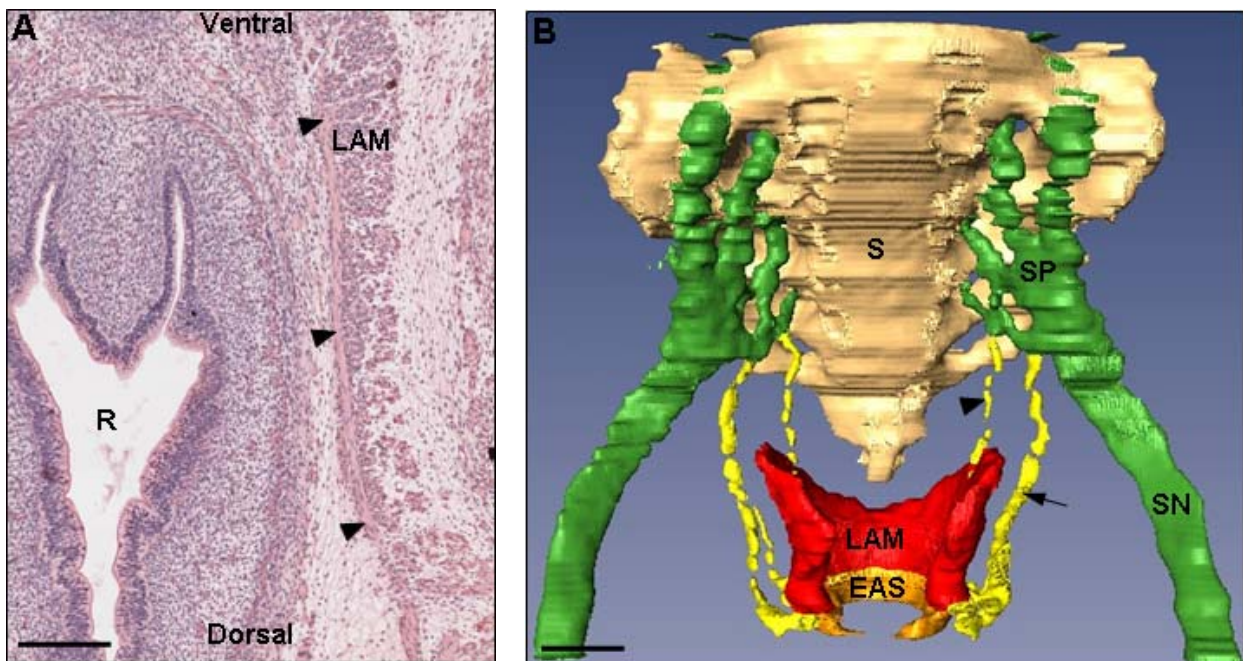
Traditionally the pudendal nerve is considered to be the main nerve innervating the pelvic floor muscles. Recent studies reveal that direct branches from the sacral plexus innervate the main muscle of the pelvic floor, the levator ani muscle, from its superior side. This was demonstrated by gross dissection (1) and nerve stimulation (2), but detailed morphological studies are lacking. Since such branches would be more prone to damage during childbirth and therapeutic interventions, exact knowledge of the anatomy of these nerves is of clinical importance. Since nerves are relatively large in foetuses, we have undertaken a study to examine whether a specific 'levator ani nerve' (LAN) can be demonstrated in human foetuses. Furthermore, we described the macroscopic anatomy of the LAN in cadavers.

### Study design, materials and methods

Two female foetal pelvises (14 & 19 weeks of gestation) were stained immunohistochemically for the presence of striated muscle and nerve tissue, as well as with haematoxylin-azophloxine. To verify the data from these two foetuses, we investigated foetal pelvic sections from the institutions' collections. These foetuses (11 females and 7 males, ranging from 10 weeks of gestation to 27 weeks of gestation) were all stained with haematoxylin and either azophloxine or eosin. Three-dimensional reconstructions were prepared. We also dissected ten female adult pelvises. The pelvises were transected midsagittally. The topographical course of the 'levator ani nerve' was described quantitatively. The foetuses were obtained after legal abortion and the study was approved by the institutional medical-ethical committee.

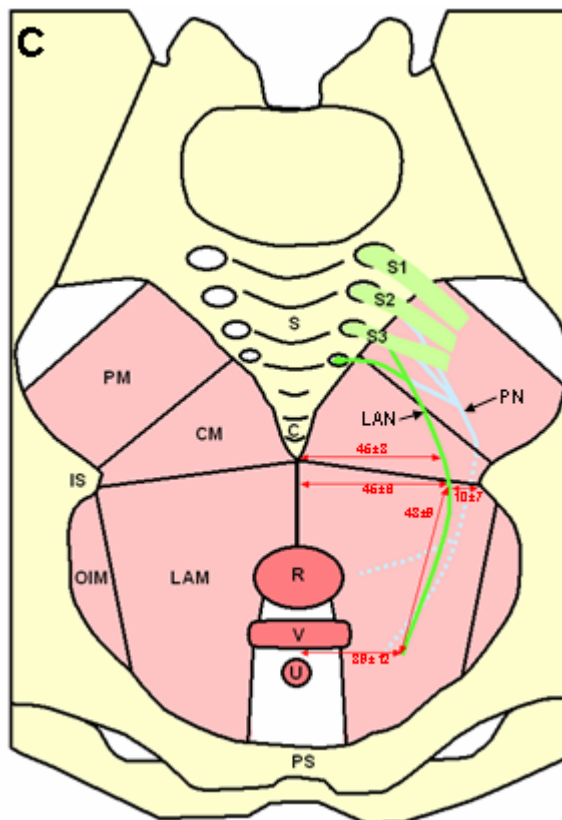
### Results

In the foetuses direct branches from sacral nerves S3/S4 innervate the pelvic floor on its superior side whereas the pudendal nerve innervates the external anal sphincter only (Fig. 1). An innervation of the levator ani muscle by the pudendal nerve could not be confirmed. Dissection of the female adult pelvises also conclusively demonstrated that the LAN originates from sacral nerves S3 and/or S4. It runs along the superior surface of the coccygeal and levator ani muscle from posterior to anterior and is situated underneath the pelvic parietal fascia. Its trajectory was situated 45 mm (range: 37-58 mm) lateral to the midsagittal plane at the level of the ischial spine, 45 mm (range: 35-60 mm) lateral to the tip of the coccyx and 10 mm (range: 3-22 mm) medio-caudal to the ischial spine (Fig. 1C). The main branch of the LAN entered the levator ani muscle where it passed the ischial spine in four pelvises and in six pelvises it continued its course further on the visceral surface of the muscle to enter it in its puborectalis portion.



**Figure 1. The levator ani nerve, innervating the levator ani muscle on its visceral side.**

**A.** Transverse section (stained with haematoxylin-azophloxine) of an 11-weeks old male foetus showing the 'levator ani nerve' (arrowheads) on the visceral side of the levator ani muscle. LAM, levator ani muscle; R, rectum. Bar = 0.2 mm. **B.** Frontal view of three-dimensional reconstruction of the 'levator ani nerves' and pudendal nerves and levator ani muscle of a 14-weeks old female foetus. Arrowhead, 'levator ani nerve', Arrow, pudendal nerve, EAS, external anal sphincter; LAM, levator ani muscle; S, sacrum; SN, sciatic nerve; SP, sacral plexus. Bar = 1 mm. **C.** Schematic overview of the topographical course of the 'levator ani nerve' in the adult female pelvis. C, coccyx; CM, coccygeal muscle; IS, ischial spine; LAM, levator ani muscle; LAN, levator ani nerve; OIM, obturator internus muscle; PM, piriformis muscle; PN, pudendal nerve; PS, pubic symphysis; R, rectum; S, sacrum; S1, S2, S3, sacral nerve trunks 1 to 3; U, urethra; V, vagina. The interrupted lines represent the pudendal nerve inferior to the coccygeal and levator ani muscle.



#### Interpretation of results

The clinical implications of these findings on the innervation of the pelvic floor are evident: denervation of the pelvic floor muscles and the ensuing muscle dysfunction can cause urinary and/or faecal incontinence and/or pelvic organ prolapse. The concept of nerve damage due to stretching and pressure during complicated vaginal childbirth or pelvic surgical procedures is easier to understand with the nerve to the levator ani muscle located on the superior, visceral side of the pelvic floor. In contrast, the pudendal nerve is better protected on the inferior side of the pelvic floor in Alcock's canal.

#### Concluding message

The pelvic floor is innervated from the superior side by branches from sacral nerves S3/S4. No contribution of the pudendal nerve to the pelvic floor innervation can be demonstrated.

#### References

1. American Journal of Obstetrics and Gynecology (2002). 187 (1), 64-71.
2. Lancet (1980). 1, 16-17.

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**FUNDING:** John L. Emmett's foundation

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**HUMAN SUBJECTS:** This study was approved by the Leiden University Medical Center Ethics Committee but did not follow the Declaration of Helsinki - with approval by the ethics committee - in the sense that no identifiable human material was used. Informed consent was not obtained from the patients.