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DETECTION OF INNERVATION ZONES AND INNERVATION ZONE DISTRIBUTION IN THE URETHRAL SPHINCTER THROUGH CIRCUMFERENTIAL SURFACE EMG

Aims of Study

Urethral sphincter electromyography is valuable in the investigation of (dys-) function of the lower urinary tract. The electromyographic method generally used in studies of the urethral sphincter is based on concentric needle electrodes or single fiber electrodes.
Aim of the study is to evaluate the circumferential surface electromyography and detect innervation zones and innervation zone distribution of motor unit potentials of the urethral rhabdomyosphincter during rest, voluntary contraction and Sacral Nerve Stimulation (SNS).

Methods

A female patient with stress incontinence was electromyographically analyzed during SNS. Electromyographical recordings were made during rest, stimulation of sacral roots S3 and S4 left and right, with and without voluntary contraction. Eight silver wire electrodes on a cylindrical probe (diameter probe 5 mm, diameter wire 0.5 mm) are placed in a circular array with a constant interelectrode distance to record 8-channel circumferential surface EMG (CSEMG). The Radon Correlation Transformation (RCT) is an algorithm developed to detect the Innervation Zone (IZ) of a motor unit from a multi channel surface EMG acquired with an electrode array.
This transformation maps linear objects of a two-dimensional domain into peaks in the transformed domain, where each line in the image will give a peak. The amplitude of the marginal distribution of the RCT generating the peaks is a function of EMG signal amplitude, number of channels of the Motor Unit Action Potentials (MUAPs), number of MUAPs in the interference pattern and number of innervation zones. The RCT is graphically represented in a circular arrangement to show the traveling components of the Motor Unit Action Potentials and the innervation zones in relation to their position in the urethral sphincter.

Results

In the graphic representation of the RCT, the Radon Plot (RP), asymmetry (difference between the left and right side of the sphincter) was seen during rest and voluntary contraction. During voluntary contraction of the urethral sphincter there is an increase of innervation zones over the sphincter left and right, compared to the situation during rest. This reflects the recruitment of MUs with different innervation zones. During stimulation of S3 left an increase was seen in innervation zones and innervation zone ditribution spreading over a greater area on the left side of the urethral sphincter. During stimulation of S3 right the same phenomenon in the right side of the sphincter was seen. During voluntary contraction an increase was seen in innervation zones and innervation zone distribution in the whole sphincter. When S4 right was stimulated an increase of innervation zones and innervation zone distrbution was seen in the whole urethral sphincter. Stimulation of S4 left gave rise to innervation zones and inneration zone distribution in both halves of the urethral sphincter.

Conclusions

Spatial differences between the left and right side of the urethral sphincter in the Radon Correlation Plot could be an indicator for functional asymmetry. A difference is noted in CSEMG between voluntary contraction and contraction mediated by sacral nerve stimulation. In the Radon correlation plot one can localize the direct reactions of sacral nerve stimulation at the level of the urethral sphincter, which could make CSEMG a method to evaluate SNS. The Radon Correlation Plot could be of help in determining the best site to place the definitive lead with respect to the reaction in the urethral sphincter.

CIRCULAR REPRESENTATION OF THE RADON CORRELATION TRANSFORM

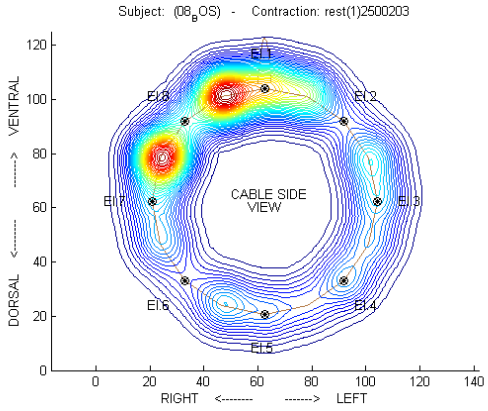

fig.1

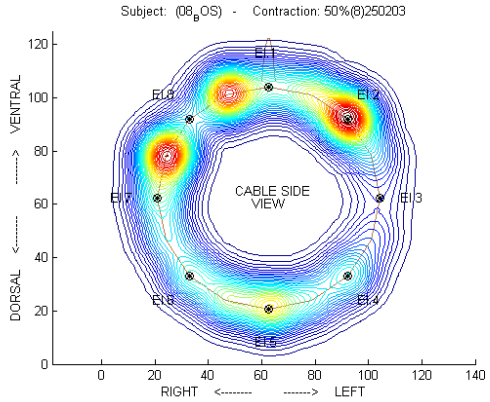

fig 2

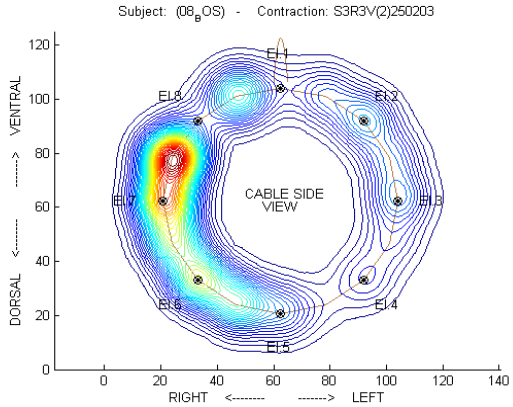

fig. 3

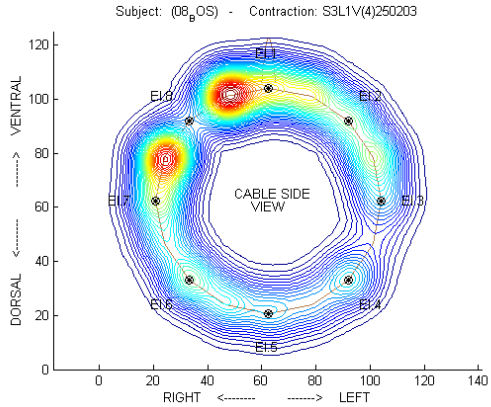

fig.4

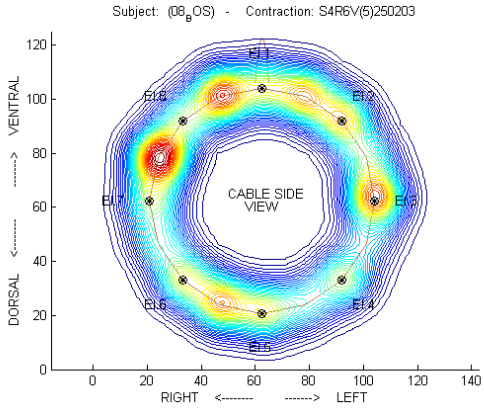

fig. 5

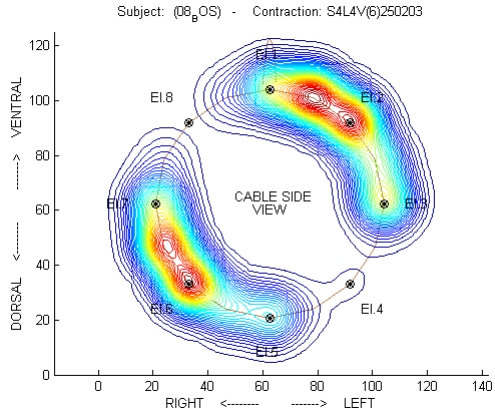

fig. 6

Figure 1: RCT of urethral sphincter during rest.
Figure 2: RCT of urethral sphincter during slight voluntary contraction.
Figure 3: RCT of urethral sphincter during stimulation S3 right with 3 Volt, 14 Hz.
Figure 4: RCT of urethral sphincter during stimulation S3 left with 1 Volt, 14 Hz.
Figure 5: RCT of urethral sphincter during stimulation S4 right with 6 Volt, 14 Hz.
Figure 6: RCT of urethral sphincter during stimulation S4 left with 4 Volt, 14 Hz.