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REPORT

Consensus and progress in corpus cavernosum-EMG (CC-EMG)

Second International Workshop on CC-EMG in Hannover/Germany, February 25 and 26, 1994

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From a functional point of view, penile erection depends on sufficient enlargement and rigidity of the cavernous bodies. These functional changes of the cavernous bodies depend on an adequate autonomic nervous input and intact cavernous smooth muscle cells with functional intercellular communications. By analogy to the EMG of the striated muscle, these factors (autonomic supply, cell intactness) should be detectable by an EMG of the cavernous smooth muscle cells. As such information could be of crucial importance for careful selection of therapeutic options for an individual patient, CC-EMG has recently gained scientific interest. To unify scientific efforts and to allow comparability of the recordings, basic parameters for the registration of the CC-EMG were agreed on during the first International Workshop on CC-EMG in 1993[1]. The aim of the Second Workshop was to evaluate how analogous recording of the CC-EMG looks in normal patients. Furthermore, it should be determined how digitalization of these data should be done; first results of such studies were presented at the present meeting.

The following researchers attended the meeting: Buchhauser, K., Wiest GmbH, München, Germany; Deronet, Harry, Homburg, Germany; Drakopoulos, Avraam, Thessaloniki, Greece; Eckert, Ralph, Homburg, Germany; Fabra, Matthias, Allgemeins Krankenhaus, Harburg, Germany; Fiter, Luis, Department of Urology, Madrid, Spain; Floth, Andreas, Donauspital, Vienna; Austia; Gerstenberg, Thomas, Herlev University Hospital, Denmark; Giraldi, Annamaria, Panum Institute, Copenhagen, Denmark; Gulino, Gaetano, Catholic University of Rome, Italy; Hauck, Ekkehard, Medizinische Hochschule, Hannover, Germany; Hinrichs, Hermann, Medizinische Hochschule, Hannover, Germany; Jünemann, K.-P., Klinikum der

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Stadt, Mannheim, Germany; Kellner, Bernd, Medizinische Hochschule, Hannover, Germany; Knudsen, Wiest Company, Unterhaching, Germany; Leontardis, N., Department of Urology, Vienna, Austria; Luther, Achim, Urologische Universitätsklinik, Ulm Germany; Merckx, L., Department of Urology, Jette, Belgium; Nahoum, Cesar, Pharmacology Faculty of Medicine, São Paulo, Brazil; Noack, Thomas, Physiologisches Institut, Marburg, Germany; Opsomer, R. J., Cliniques Saint-Luc Bruxelles, Belgium; Pereira da Silva, José, Clinica Harmonia Lisboa, Portugal; Pettirossi, Orlando, Impotence Center Trieste, Italy; Pickl, Ulrich, Klinikum rechts der Isar der TU, München, Germany; Reuten, Jos, Academic Hospital, Maastricht, The Netherlands; Sasso, Francesco, Catholic University of Rome, Italy; Schlote, Norbert, Medizinische Hochschule, Hannover, Germany; Schmedemann, Reiner, Upjohn GmbH, Heppenheim, Germany; Schou, Jesper, Herlev University Hospital, Denmark; Sprecher, Elliot, Rambam Medical Center, Haifa, Israel; Stief, Christian, Medizinische Hochschule, Hannover, Germany; Taher, Akmal, Department of Urology, Jakarta, Indonesia; Truß, Michael, Medizinische Hoschschule, Hannover, Germany; Ückert, Stefan, Medizinische Hochschule, Hannover, Germany; van Driel, Mels, University Hospital Groningen, The Netherlands; Vardi, Yoram, Rambam Medical Center, Haifa, Israel; Vryhof, Eric, University Hospital, Maastricht, The Netherlands; Wagner, Gorm, Panum Institute, Copenhagen, Denmark.

The first section of the workshop dealt with basic research into cavernous electric activity. After reviewing basic smooth muscle electrophysiology, Noack presented his patch clamp findings on cavernous smooth muscle cells showing chloride currents to be of importance for the cavernous membrane potential. Eckert, applying the whole-cell patch clamp technique, offered further insight into calcium regulation within the cavernous smooth muscle cell. Wagner then elucidated the process of the composition of the cavernous electric activity in vivo and explained the influence of tissue intactness and electrode placement on the potential(s) recorded.

In contrast to the first workshop where the recordings presented were difficult to compare due to highly different recording parameters and conditions, the clinical data presented (Hauck, Gerstenberg, Vryhof, Fabra, Leontardis, Merckx, Pörtner, da Peireira) for normal subjects now were comparable in all but one group (Vardi). It was agreed that CC-EMG in normal subjects (frequency range 0.5 to 20 Hz, surface or needle electrode) consists of phases of electrical silence or slow wave activity of low amplitude, irregularly interrupted by spike potentials (amplitude 120–>500 μV). These potentials are highly reproducible within the individual subject and they are mostly of comparable shape between individuals. When recorded with two concentric needle electrodes bilaterally, there were comparable potentials at the same time in both cavernous bodies in more than 90% of the cases. There was no statistical significance in the difference of potentials between younger and older subjects, although there was a trend towards lower amplitude and shorter duration in the elderly. Gerstenberg reported a disappearance of CC-EMG during tumescence to visual sexual stimulation, whereas during full erection, low amplitude electrical activity was seen. Fabra presented a 66% reproducibility for CC-EMG during flaccidity that increased to over 80% when Valsalva manoeuvers, provoking 'tSP' (typical SPACE potentials) in most patients, were added. L. Merckx will collect all data for normal subjects from the different groups and present these in a separate paper.

Schou reported on a study of CC-EMG before and after TUR-P (transurethral resection of the prostate) where he found no differences, but highly reproducible recordings of the CC-EMG during flaccidity 6 months after the first; when visual sexual stimulation (VSS) was applied, the reproducibility of the CC-EMG during that period fell below 50% due to the inconsistent erectile response. Merckx presented data that showed a correlation between smooth muscle content in penile biopsies and the potential amplitude. Sasso compared the CC-EMG of normal subjects to patients having undergone radical cystectomy and found significant changes in potential amplitude and frequency.

Digitalization and computer-aided analysis of the CC-EMG (Jünemann, Kellner, Nahoum, Sprecher) made an important step forward compared to one year ago. Jünemann reported that the source information of the CC-EMG is located in the potential(s) and that the periods in between (phases of electrical baseline or wavelike activity of low amplitude and low frequency) contain no information. He reported a high degree of autocorrelation of the potentials within the individual patient and specific patterns for different aetiologies. Kellner and Jünemann showed data files before and after artifact elimination, making extraction of artifacts mandatory before computer-aided analysis. Kellner presented computerized data and fast Fourier transformations (FFT) in larger groups of normal subjects of different ages and found only minor differences. However, compared to patients with erectile dysfunction due to well defined lesions, marked differences in the FFT were seen. In the normal subject, all groups demonstrated an identical distribution of the signal intensity in the FFT with more than 90% of the intensity below 1.5 hz and less than 2% above 5 Hz.

Based on the above results, it was generally agreed that, applying the criteria of the First International Workshop[1], CC-EMG recording in the normal subject during flaccidity results in reproducible findings throughout the specialized centres. The information of CC-EMG in normal subjects during flaccidity is located in the potential(s) itself (shape, amplitude, duration, polyphasity for analogous recording) and not in its occurrence in time or in the intervals between the potentials. Due to difficulties in reproducibility, the value of the application of VSS and pharmacological provocation remains unclear and needs further studies.

In order to reach further broadly based insights into the possibilities of CC-EMG, it was further agreed to compile large amounts of data in patient groups with erectile dysfunction and definite lesions. Since age may play a role in CC-EMG with statistical differences only in large series, normal subjects of different age groups should also be evaluated further.

The next International Workshop on CC-EMG will be organized by Thomas Gerstenberg and be held 10 and 11 March 1995 in Copenhagen. In order to present at this workshop, you will have to fulfil the following minimum criteria:

RECORDING

- —analogous or digital
- —surface or concentric or monopolar needle, placement see *Int. J. Impotence Res.* (1993) **5**: 107
- —examiner present in the room noting possible artifacts
- —flaccidity with recording (for interpretation) started 30 min after electrode placement

—frequency range 0.5 to 10 Hz (or a wider range)
—for analogous recording a gain of 100 to 1000 full scale with increment steps of 1, 2, 5 and 10; paper speed as to enable a sufficient characterization of the potentials (5 better than 1 mm/second)
—for digital recording: 3 times Valsalva manoeuver (15 seconds expiration with 40 mmHg) after 30 min with a minimum interval of 1 min (question: are the potentials obtained comparable to the ones spontaneously occurring?)

Patient groups

—at least 10 patients for each group
—aetiology/case history: upper neuron lesion (spinal cord injury); lower neuron lesion (extensive radical surgery in the small pelvis; e.g. radical cystectomy or abdomino-perineal extirpation of the rectum); diabetes mellitus (type 1 and 2) >5 years

Furthermore, the research should focus on standardization of VSS and on possible additional information compared to the CC-EMG during flaccidity.

For the groups working with digital data it will be important if the frequency range chosen on the basis of the analogous recording is appropriate. We know that most of the important signal information is below 2 Hz, but we do not know if the frequency band below 0.5 or 0.3 Hz or even lower is of clinical interest. Thus, data acquisition down to 0.015 Hz will be done by several groups and the results will be presented.

Since there is no (more) supplier of a specifically designed hardware to do analogous or digital CC-EMG recording, K. P. Jünemann (Department of Urology, Städt Kliniken, D-68135 Mannheim) has agreed to provide specific, custom-made hard- and software at a self cost price.

General hardware recommendations for the digital CC-EMG recording

The configuration that is used in the Department of Urology at the Hannover Medical School is printed in brackets [ ].

1. CC-EMG recording unit
   —analog output for ⩾2 channels
   —frequency range: 0.5 Hz (or lower) to 20 Hz (or higher) [0.5–100 Hz]
2. IBM-compatible computer for digital signal processing
   —486 DX33 or higher [486 DX33]
   —hard disc capacity 120 MB or higher [425 MB]
   —3.5″ floppy disc [3.5″/5.25″]
3. Analog low pass filter
   —should be used to prevent aliasing effects and to protect the A/D-converter
   —cut-off-frequency depends on the highest frequency to be detected (see para. 1). Should be considerably higher (e.g. 50%) than the highest frequency of interest, because with ordinary analog filters the gain decreases and phase is distorted clearly below the cut-off-frequency [64 Hz]
4. A/D-converter
   —PC-slot-card
   —resolution: 12 bit or higher [12 bit]

— sampling frequency: depends on the highest frequency passing through the analog low pass filter. Should be at least twice the cut-off-frequency (Shannon's sampling theorem!). With respect to the limited steepness of the filter's slope it is recommended, to choose sampling frequency considerably higher than twice the cut-off-frequency (e.g. three or four times) [170.6 Hz]
— the voltage input range should correspond to the voltage output range of the CC-EMG recording unit

CONVENTIONS FOR THE BINARY STORAGE OF DIGITIZED CC-EMG DATA

The patient data files should always start with the following information header:

Position	Variable	Significance
1 . . . 9	IDENT	patient information block
10	DAY	recording day
11	MONTH	recording month
12	YEAR	recording year
13	HOUR	recording hour
14	MIN	recording minute
15	RECFORM	0: surface; 1: monopol.; 2; bipol. elec.
16	SEGL	FFT segment length, specified as number of samples
17	SAMPER	sampling period (<100: ms; $\geqslant 100$: μs)
18	SPECWIN	spectral window type
19	OVERLAP	0: no; 1: half overlapping segments
20	CHANNEL	number of channels
21 . . . 53	—	***unused***
54 . . . 63	SEGNUM	number of transformed segments per channel
64 . . . 73	ARTNUM	number of artifact segments per channel
74 . . . 151	VARTEX	free text
152, 153	DF	delta f (frequency stepwidth) in Hz
154 . . . 185	—	***unused***

After this information header the unmodified sampling values should be stored according to the following scrambled structure:

sampling value channel 1 sampling value channel 2 and so on.

The raw data has to be stored in a 2-byte integer value in binary form, right-justified and inclusive sign.

FORTRAN-DECLARATION

```
character     VARTEX*156, IDENT*18
character*2   DAY, MONTH, YEAR, HOUR, MIN
integer*2     RECFORM, SEGL, SAMPER, SPECWIN, OVERLAP
integer*2     CHANNEL, SEGNUM(10), ARTNUM(10)
real*4        DF
```

CODES FOR THE SPECTRAL WINDOWS

0 = none, 1 = Bartlett, 2 = Tukey, 3 = Parabolic

PLEASE NOTE

The Third International Workshop on CC-EMG will take place on 10 and 11 March 1995 in Copenhagen. For further details please write to: Dr Th. Gerstenberg, Department of Urology, Herlev Hospital, DK—2730 Herlev, Denmark, Tel: +45 44 535300, Fax: +45 44 5352332