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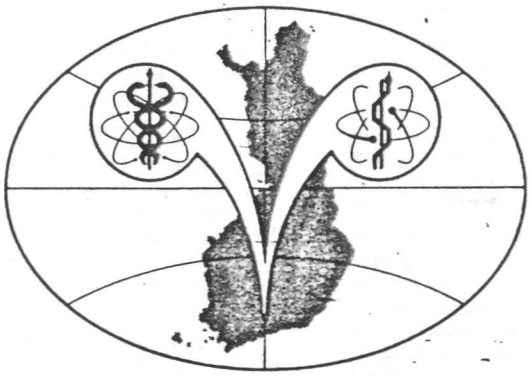

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SIGNAL PROCESSING OF HUMAN PARTURIENT UTERINE CORPUS AND CERVIX ELECTROMYOGRAPHY - A NEW APPROACH TO QUANTIFIED CLINICAL MONITORING OF LABOUR

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INTRODUCTION

In normal pregnancy the human uterus remains almost inactive until the 40th week of gestation, when its activity becomes very intensive and coordinated. The recording of uterine contractions is routinely done by external monitoring of the strength of contractions by tocodynamometry or more accurately by tocographic monitoring of intrauterine pressure rises in the amniotic fluid. It has been shown that the detailed mechanics of the myometrium escapes measurement. Simultaneous recording of myometrial electrical activity, which yields far more information on its contractile mechanisms, has been experimentally used by some investigators (1, 2). Abdominal or intrauterine electromyographic recording, which reflects the original process of the myometrial smooth muscle fibres excitation, has mostly been studied qualitatively. Until very recently little quantitative information on the evolution of the uterine electrical contractile behaviour during labour, particularly in the human, has been available (3). This is essentially due to the technical difficulties encountered in recording and processing the abdominal EMG. In the first studies the uterine electromyogram was considered a deterministic signal and the data in the form of average amplitude, duration and frequency of bursts of activity were not sufficient to describe electrophysiological parameters.

Our aim was to categorize the uterine corpus and cervix electrical potencials not only by visual observations but also by the techniques used in random stationnary signal computer processing methods, which combine amplitude, shape as well as time characteristics. We wanted to derive the clinically applicable parameters which should be helpful in the menagement decisions and evaluation of the slow labour progress due to abnormal uterine contractions and slow cervical dilatation. For this purpose spectral analysis of the potencials monitored in cervix with different maturity and parity and by the comparison of the uterine corpus EMG was introduces. Our study was focused on the activity of smooth cervical muscles (4), which have so far not been recognised and studied, but are important' for the normal course of labour, as proved by some other histological studies (5).

RECORDING AND INFORMATION-PROCESSING TECHNIOUES

In solving problems of reliable detection of uterine EMG activity our starting point was the use of standard electropysiological equipment which is nowadays available in any delivery room. It is necessary for monitoring high risk labours and for active menagement of induced labours. Differential uterine corpus and cervix EMG detection has been described in detail elsewhere (6).

A miniature two-channel differential EMG preamplifier with the gain of 5000 was designed which offers three inputs and the possibility of amplifying different combinations of two out of the three EMG signals being connected (i.e. corpus and/or longitudinal cervical fibres and/ or circular cervical fibres EMG signals) The preamplifier is very easily mounted to the parturient woman's thigh. It enables sufficiently artefact free recording and amplification of the signals detected by abdominal disk electrodes and

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cervical spiral electrodes otherwise used in fetal ECG monitoring. The selected combination of only two EMG signal tracings was due to limitations of the standard equipment. As a recorder, the two-channel thermal chart recorder of the cardiotocograph HP8030A was used. Its applicability was adapted to permit the selection between recording intrauterine pressure and cardio fetal beats (standard cardio-tocography) and recording EMG activity either on both channels or on one channel in combination with the intrauterine pressure on the other. Both amplified and filtered EMG signals were recorded for computer analysis on magnetic tape-recorder in FM.

The quantitative analysis of changes in amplitude and frequency parameters of the EMG signal has so far mostly been used in studies of activation and fatigue of striated skeletal muscles. In our study, the spectral analysis was computed by applying fast Fourier transformation algorithm to 2048 samples of recorded EMG signal. Thus amplitude and power spectral density function (PSDF) was estimated. To study changes in PSDF, alterations in mode, mean and median frequencies were observed. These frequencies were defined as the frequency of the maximal power spectral component, the mean frequency present in the power spectrum and the frequency at which the area of the PSDF is divided in two equal parts. To reduce side lobe effects and aliasing the Hanning tapered data window was used during transformation of sampled data from time-domain to frequency-domain. The EMG analysis was performed on an automatic desktop 16-bit microcomputer system. The software package developed for this purpose enabled the following procedures: -sampling of the EMG signal s by programmable parameters for sampling frequency, number of samples and amplitude range of the signal,- the selection. of time sequence which is arbitrarily extracted from the entire set of samples and - spectral analysis of the data sequence. The optimal conditions for the signal , which was filtered to 0,1 Hz and under 10 Hz, were chosen: sampling frequency 128 Hz, number of samples in the set 10000, number of samples in the sequence 2048, duration per sequence 16 seconds. These parameters enabled the pro per frequency resolution of 0,0625 Hz

RESULTS AND DISCUSSION

The above programs enabled precise observations of changes in amplitude and frequency content of EMG signals from different parts of the uterus at any selected moment. As a rule, EMG signals were sampled inbetween two uterine contractions, while there was no intrauterine pressure and during uterine contractions, that is at the increase of the intrauterine pressure. In both of these characteristic intervals several sequences defined by the program were analysed. The computed amplitude and power spectral density functions were then plotted in normalized scale.

Figure 1, 2 and 3 represent recordings of the measured signals on the oscilloscopic screen and' the power spectra of two uterine EMG signals before and during contraction in two different phases of a labour. The case presented here illustrates one of the mechanisms- of cervical activity that can be identified by means of the method developed in our study. The initial weak activity of higher frequencies (median frequency- 2,5 Hz, mean frequency -2,9 Hz and mode frequency - 2,18 Hz) in the first hour of the first phase of labour became 30 minutes after induction by oxytocin very sinchronized (median frequency -0,25 Hz, mean frequency - 0,45 Hz and mode frequency -0,31 Hz) and very intensive. The ratio between maximal final and initial power spectral components was about 50. Contrary to this the corpus activity was more synchronised immediately before the onset of the intrauterine pressure rise (median frequency - 0,19 Hz, mean frequency - 0,4 Hz and mode frequency - 0,25 Hz) and it persisted throughout the whole labour very similar.

The most typical phenomena observed in both EMG signals power spectra are the several peaks which are always at the similar frequencies only the amplitude and thus the power density of these frequencies is changing throughout the labour. Such phenomena were noticed in all the 5 cases submitted to the

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described microcomputer analysis. The power frequency spectra in striated skeletal muscles are known to depend on a number of physical factors, such as the positioning of the recording electrodes, the shape of the muscle unit action potential and the muscle conduction velocity, muscle unit size and distance from the electrodes and their firing rate and recruitment state. Similar studies should be extended to smooth muscles of a parturient uterus. We already dericted our detailed study to detect separately the longitudinal and circular cervical muscle fibres which are different in their anatomy and functional correlation to the corpus of uterus.

CONCLUSIONS

Detailed results and conclusions of our study of EXG activity of uterine corpus and cervix during 60 labours , which may be found in (5) represent new findings in the field of smooth muscle activity and functioning. The results are very promising specially in the way they show the possibility of diagnosing the unmature cervix and thus enable the better menagement of the labour.

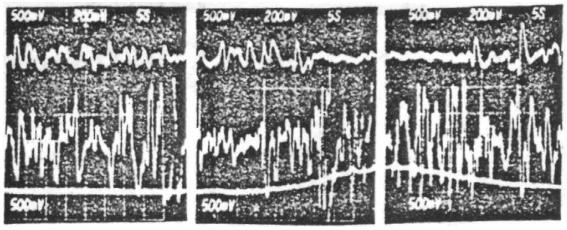

Figure 1.a.: Primipara,M.R.,60 min. of the first pha se of labour after amniotomy. Photos from the oscilloscopic screen during replay which present simultaneous EMG activity of uterine corpus (upper tracing, sensitivity 50uV/div.) and *cervix (m~ddle tracing, sensitivity 20uv/div)* and *intrauterine pressure (lower tracing8kPa/div.) - Cervical dilatation 1,* 5 cm.

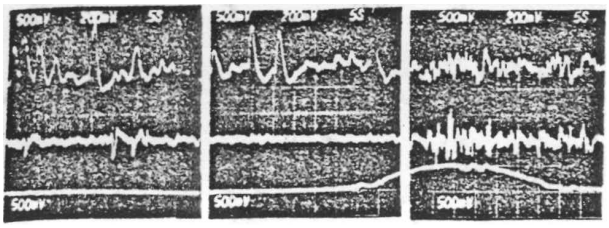

Figure 1b.:The same *patient, pr~m~para, 30 min. after* stal *of oxytocin infusion at a* rate 6,75 *mE/min., at the beginning of rapid dilatation phase. The same tracings, the sensitivity for both EMG signals is doubled.*

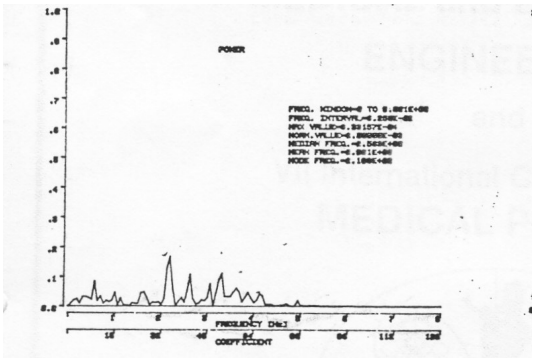

Figure 2.a.: PSDF of uterine cervix EMG signal which belongs to the third photo in Figure 1.a., ·i.e. during the uterine contraction when the activation is most pronounced.

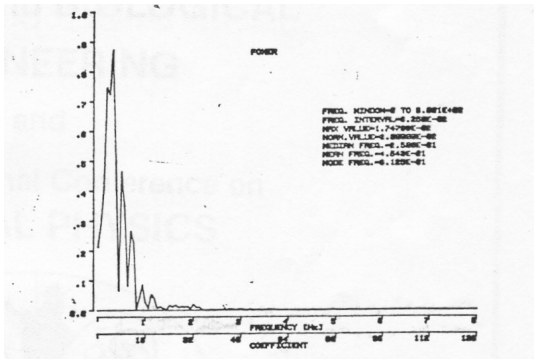

Figure. 2.b.: PSDF of uterine cervix EMG signal which belongs-to the third photo in Figure 1.b., i.e.during the uterine contraetion.

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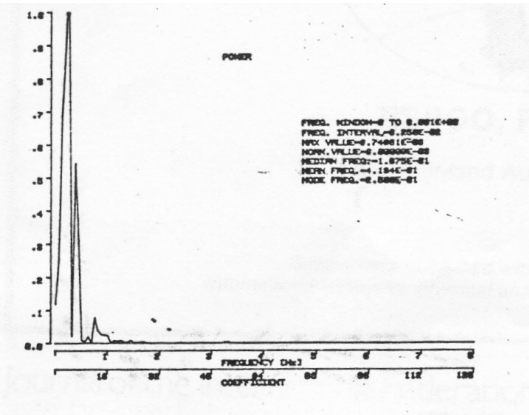

Figure 3.: PSDF of uterine corp us EMG signal which bel on g: to the first photo in Figure l.a., before the intrauterin pressure rise

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