1.

Proceedings of the
8th International IMEKO Conference on
Measurement in Clinical Medicine

BIOMEDICAL MEASUREMENT AND INSTRUMENTATION

DUBROVNIK - CROATIA
September 16-19, 1998

Time/frequency analysis of the uterine EMG in pregnancy and parturition in sheep

Brane Leskošek*, Marjan Pajntar*, Drago Rudel**

*University Medical Centre Ljubljana, Dept. Of Obstetrics and Gynecology, Research Unit, Šlajmerjeva 3, SI-1000 Ljubljana, Slovenia

**Faculty of Medicine, Institute of Social Medicine, Zaloška cesta 4, SI-1000, Ljubljana, Slovenia E-mail: brane.leskosek@kclj.si.maIjan.pajntar@kclj.si.drago.rudel@mf.uni-lj.si

Abstract

The aim of this study was to evaluate the electromyographic (EMG) activity of smooth musc1es of uterine cervix (UC) and uterine horn (UH) in sheep during pregnancy and parturition in time/frequency domain and to recognize the differences between the two activities.

The uterine electromyographic activity was recorded in eight sheep by electrodes, surgically implanted on UC and UH during pregnancy, parturition and postpartum. The data was sampled and stored digital1y on a PC computer in real time. All data processing was made off-line in the time/frequency domain.

The results of the time/frequency analysis showed that the activity in UC and UH was changing during different observed periods and that there are differences between the musc1es activity in UC and UH.

The use of the time/frequency distribution (TFD) bas been recognized as a successful method for analysis of smooth muscles activity in the UC and UH during pregnancy and parturition in sheep.

Keywords

electromyography, uterus, sheep,

time/frequency distribution, spectrogram

1. Introduction

The role and activity of the smooth musculature in the cervix in pregnancy and in parturition has not been thoroughly investigated yet. In pregnancy the cervix has to retain the conceptus, whereas during parturition it should dilate and retract. Thus, during pregnancy the smooth muscles in the cervix (spiral or circular fibres) should by contracting contribute to the closure of the cervical canal, whereas during parturition other lyers of smooth musc1e (longitudinal fibres) should actively contribute to the dilatation and retraction of the cervix (Pajntar et al.1987, Pajntar et al. 1991, Pajntar 1994).

With measurements of cervical and uterine pressure Stys et al. (1978) showed that the cervical and uterine smooth muscles appear to act independently in sheep, possibly reflecting their separate functions. The cervix was found to contract rhythmically and vigorously with gradual decrease in activity as parturition approached.

Over the last few decades, the uterine electromyographic (EMG) activity bas been investigated in humans and several animals (Wolfs and Van Leeuwen 1979, Harding et al. 1982, Garcia-Villar et al. 1982, Toutain et al. 1983, Garcia-Villar 1984, Devedeux et al. 1993, Troedsson et al. 1993). Most studies measured the EMG activity in the uterine corpus, whereas our group have focused on measuring the cervical EMG activity first in humans during parturition (Pajntar et al. 1987, Pajntar and Rude1 1991, Pajntar and Verdenik 1995, Pajntar et al. 1998) and now in sheep in pregnancy and parturition.

With development of the computer technology and because the classical manual methods such as burst counting have not given the expected results, the emphasis has been given on using the already developed mathematical tools and on developing new tools for analyzing the EMG data (Duchene et al. 1995). The aim of this study was to evaluate the electromyographic (EMG) activity of smooth musc1es of uterine cervix (UC) and uterine horn (UR) in sheep during pregnancy and parturition in time/frequency domain and to recognize the differences between the two activities.

2. Methods

To eight sheep which were pregnant two to three months and were not dams for the first time, we surgically implanted platinum bipolar electrodes (two pairs of active electrodes and one reference electrode) on the UC and UH (Figure 1). The EMG activity from the UC (channel2 in Figure 1) and UH (channel 1 in Figure 1) was recorded in circular direction twice per day during pregnancy, during entire parturition (up to ten hours) and twice per day for seven days after delivery. During pregnancy and after parturition each recording session lasted about one hour. EMG signals were fed to the differential EMG amplifying system with integrated active analogue lowpass filter (passband edge frequency f_p=4,6Hz/3dB) and then recorded with personal computer with installed AID converter card (sampling frequency f_s=20Hz). 1?e measuring procedure was adjusted to rout1De measurements that were operated by a trained measurer.

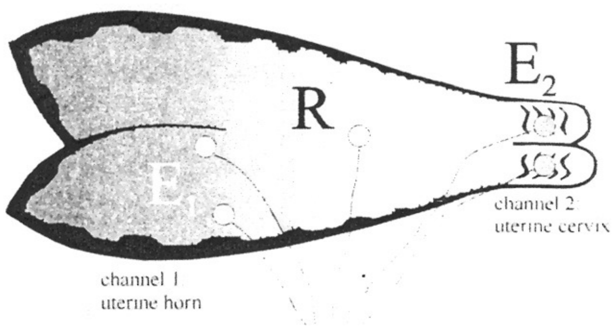

Figure 1: Positioning of electrodes on the uterine horn and uterine cervix.

The EMG signals were digitally filtered with bandpass filter (bandwidth B=from 0,08Hz to 5Hz). The average power spectrum density (PSD) was calculated for 1minute intervals for the three observed periods (pregnancy, parturition, postpartum) and for both measuring channels (UC and UR) separately. From the average PSD the time/frequency distributions spectrograms for each time period were formed. An example of a spectrogram for sheep D for all three periods and for both measuring channels (UC and UR) is shown in Figures 2 and 3, respectively. The spectrogram is a three-dimensional diagram. The abscissa (x -axis) represents the frequency in Hz, the ordinate (y-axis) represents the time in minutes, and the z-axis represents the power spectrum density in arbitrary units. The resolutions of y and z-axis were always the same, whereas the resolution of x-axis was dependent on the duration of recording sessions included in each observed period.

3. Results

Our working hypothesis was that the parameters of the uterine (UC and UR) EMG signals in sheep during pregnancy, parturition and postpartum are in relation with uterine condition in these periods.

The results that can be clearly seen only from the spectrograms are the following:

1. The activity in the UC is higher than the activity in UR during pregnancy (spectrogram a in Figures 2 and 3) and decreases in parturition (spectrogram bin Figures 2 and 3), whereas the activity in UR is lower than the activity in UC during pregnancy (spectrogram a in Figures 2 and 3) and increases during parturition (spectrogram bin Figures 2 and 3). After parturition both activities decrease (spectrogram c in Figures 2 and 3);
2. During pregnancy and parturition the activity in higher frequencies (more than 1 Hz) successively rises, whereas the low frequency content (around 0,3 Hz) is present all the time. After parturition the higher frequency content decreases and the low frequency content is almost completely absent in some l-minute intervals.

4. Discussion

Electromyogram recordings and analysis of the uterine smooth muscles have been performed quite extensively since the 1950s in humans and animals (Nixon 1951, Wolfs and Van Leeuwen 1979, Harding et al. 1982, Garcia-Villar et al. 1982, Toutain et al. 1983, Garcia-Villar 1984, Pajntar et al. 1987, Pajntar and Rudel 1991, Devedeux et al. 1993, Troedsson et al. 1993, Pajntar 1994, Pajntar and Verdenik 1995, Pajntar et al 1998). The material used and methods applied for signal analysis have been numerous. According to Devedeux and coworkers (1993) this variety need not to have deleterious consequences on the validity of the results, provided minimum of precautions are taken in their interpretation. Most authors have analyzed electrical activity defined as the number of activity bursts per defined period, mostly an hour. We have found that at the onset of induced parturition in humans, the EMG activity is irregular and not grouped into pronounced bursts (Pajntar et al. 1998). Therefore, the quantitative measures such as burst duration and intensity of bursts (Wolfs and Van Leeuwen 1979), and subjectivity of visual assessment was found to be inadequate. Consequently, we decided to use the mathematical processing of the signals and to represent the changes in EMG signals in the time/frequency domain by using spectrograms.

There is always a doubt if the signal truly reflects the uterine EMG activity. Namely, there are all sorts of artifacts, resulting from the muscle activity of abdominal wall and organs in the vicinity of the uterus. In order to obtain comparable uterine EMG recordings, we must take into consideration some factors such as: type of electrodes, positioning of electrodes and interelectrode distance, skin impedance, etc. (Pajntar and Rudel 1991). To minimize the influence of these factors, we were using a precise and uniform protocol for recording the EMG. Because of using the protocol we were able to reliably compare all calculated parameters of EMG recordings in different sheep. We presume that the parameters in the frequency domain (MF and PSD) and in the time/frequency domain (TFD) are better than the parameter in the time domain (RMS) because the frequency content of the signal is less dependent on the artifacts than the absolute value of the signal. In evaluating the uterine EMG, the roles of parameters in frequency and time/frequency domains have not been completely clarified yet.

In our study we have found the EMG activity presentation in time/frequency domain (spectrograms) very useful By using spectrograms we have confirmed the findings in sheep by some other authors (Toutain et al. 1983, Garcia-Villar 1984) that the activity in the cervix is different from the activity in other parts of uterus during pregnancy and parturition.

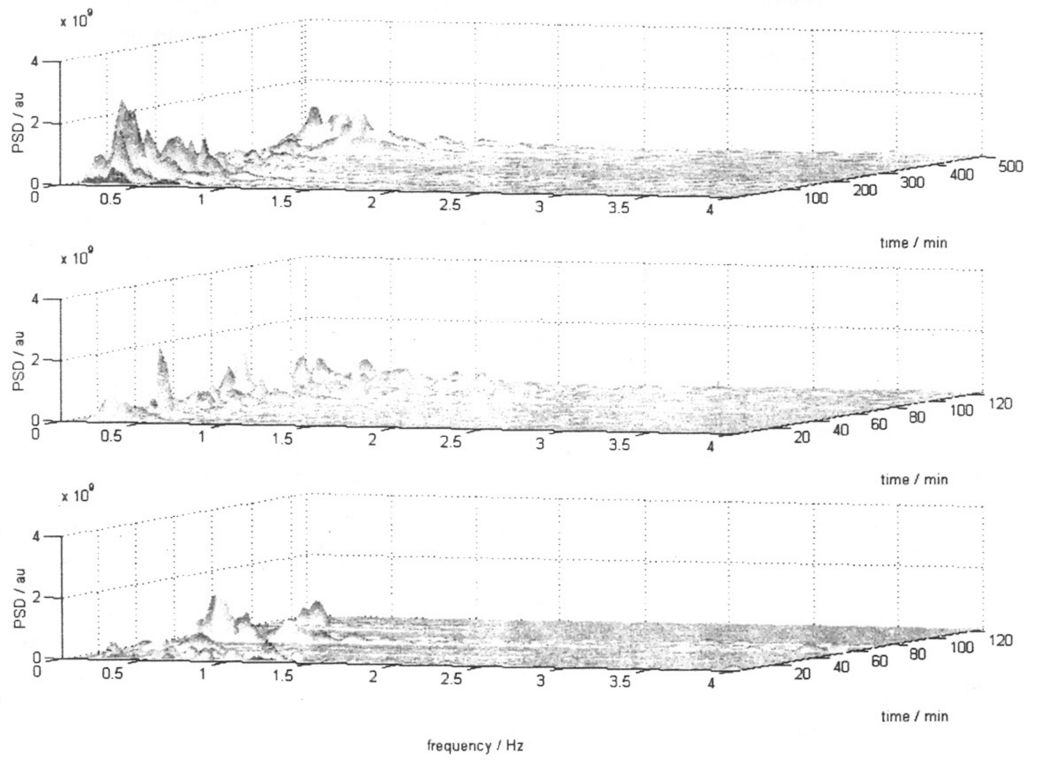

Figure 2: Spectrograms of the uterine cervix in three observed periods in sheep D.

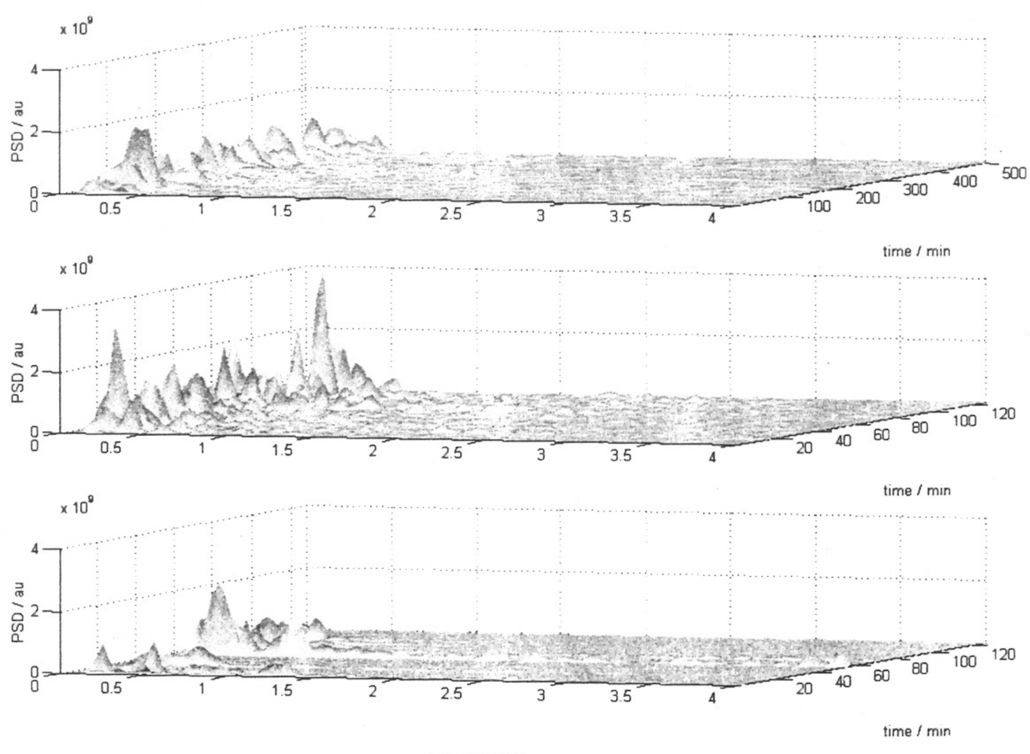

Figure 3: Spectrograms of the uterine horn in three observed periods in sheep D.

For the automatic machine recognition among different periods of pregnancy and parturition from EMG signals, suitable parameters mainly in time/frequency domain will have to be defined.

5. Conclusions

We can conclude that the uterine EMG activity of the smooth muscles of UC and UR in sheep is connected with the observed periods during pregnancy and parturition. The analysis in the time/frequency domain has proved suitable for uterine EMG. We can confirm that the activity in the UC is different from the activity in the UR during pregnancy and parturition.

Acknowledgements

The Slovenian Ministry of Science and Technology financially supported this project. We thank Dr. 1. Rozman for providing the electrodes and Dr. B. Zorko for surgical implantation of the electrodes.

References

1. Devedeux D, Marque C, Mansour S, Germain G, Duchene 1. Uterine electromyography: A critical review. Am J Obstet Gynecol 1993; 168: 1636-1653.
2. Duchene J, Devedeux D, Mansour S, Marque C. Analyzing uterine EMG: Tracking Instantaneous burst frequency. IEEE Eng Med & Biol 1995; 3(4): 125-32.
3. Garcia- Villar R, Toutain PL, More J, Ruckebusch Y. Spontaneous motility of the cervix in cyclic and ovariectomized ewes and changes induced by exogenous hormones. J Reprod Fert 1982; 66:317326.
4. Garcia- Villar R, Toutain PL, Ruckebusch Y. Pattern of electrical activity of the ovine uterus and cervix from mating to parturition. J Reprod Fert 1984; 72:143-152.
5. Harding R, Poore ER, Bailey A, Thorburn GD, Jansen CAM, Nathanielsz PW. Electromyographic activity of the nonpregnant and pregnant sheep uterus. Am J Obstet Gyneco11982; 142:448-57.
6. Nixon WXW. Uterine action, normal and abnormal.
Am J Obstet Gynecol 1951; 62:964-984.
7. Pajntar M, Roškar E, Rudel D. Electromyographic observations on the human cervix during labour. Am J Obstet Gyneco11987; 156:691-697.
8. Pajntar M, Rudel D. Changes in electromyographic activity of the cervix after stimulation of lab our with oxytocin. Gynecol Obstet Invest 1991; 31:204-207.
9. Pajntar M. The smooth muscles of the cervix in labour. Eur J Obstet Gynecol & Reprod Biol 1994; 55:9-12
10. Pajntar M, Verdenik I. Electromyographic activity in cervices with very low Bishop score during labor. Int J Gynecol Obstet 1995; 49:277-281.
11. Pajntar M, Verdenik I, Pušenjak S, Rudel D, Leskošek B. Activity of smooth muscles in human cervix and uterus. Eur J Obstet Gynecol & Reprod Bio11998 (in press).
12. Stys S, Clewell WH, Mechia G. Changes in cervical compliance at parturition independent of uterine activity. Am J Obstet Gynecol 1978; 130:414-418
13. Toutain PL, Garcia-Villar R, Hanzen C, Ruckebusch Y. Electrical and mechanical activity of the cervix in the ewe during pregnancy and parturition. J Reprod Fert 1983; 68:195-204.
14. Troedsson MHT, Wistrom AOG, Liu IKM, Ing M, Pascoe J, Thurmond M. Registration of myometrial activity using multiple site electromyography in cyclic mares. J Reprod Ferti11993; *9912:299-306.*
15. Wolfs GMJA, Van Leeuwen M. Electromyographic observations on the human uterus during labour. Acta Obstet Gynecol Scand Suppl 1979; 90: 1-62.