UTERINE CONTRACTION EFFICIENCY : A NEW MONITORING SYSTEM

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ABSTRACT

The most commonly used parameter in classical obstetrical monitoring remains the external tocography. This paper is intended to point out the possibility of using the uterine Electromyogram as an indicator of contraction efficiency for parturition monitoring.
The uterine electrical activity is recorded by means of abdominal electrodes and analyzed in order to obtain significant information related to contraction efficiency during labour. A monitoring device allows the real-time computation of an efficiency criterion suitable for obstetrical monitoring purposes. Several clinical situations are analysed in order to prove the criterion accuracy.

INTRODUCTION

Classical obstetrical practice includes uterine activity monitoring in two different ways : an external recording method, referred to as external tocography, allows the measurement of the abdominal wall deformations due to the mechanical effect of uterine contractions and then qualifies the rate of appearance of contractions. An internal recording method can be used for quantitative measurements : the Intra Uterine Pressure, IUP, picked up by means of an intra-uterine catheter. Due to the invasive way of the measurement, IUP is not suitable for usual obstetrical practice (i.e. pregnancy monitoring).

Several authors attempted to evaluate uterine activity by means of a non-invasive measurement of the electrical myometrial activity. The Electrohysterogram, EHG, recorded by means of abdominal electrodes actually represents the electrical command of the contraction. As the trigger of the contraction, it should be much more representative of the physiology of uterine activity than the mechanical consequence, IUP, and therefore would provide an attractive way of monitoring uterine activity.
This electrohysterogram was studied a long time ago by DILL and MAIDEN [1946] or StTEER [1954] and more recently by PLANES and al. [1984]. The signal, recorded by abdominal electrodes, was described as a "show" electrical wave (frequency band O.O3 - 0.1 Hz, amplitude 1 - 5 mV) on which a "fast" electrical activity (frequency band 0.3 - 2 Hz)

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is superimposed. When EHG was recorded simultaneously by internal and abdominal electrodes, HON and DAVIS [1958] , WOLF and ROTTINGHUE [1970] found a good temporal relationship between the two signals. Changes in the contractile activity occuring from the last month of pregnancy to parturition are consequence of two phenomena : increase of the cell excitability (FUCHS [1983]) and changes in the temporospatial organisation (CALDEYRO-BARCIA and POSEIRO [1960]).

The kind of propagation is modified between pregnancy and parturition, gap junctions appear just before and during the first steps of the labor, then the electromyogram (particularly its spectral characteristics) will offer useful information on the command signal. By defining reference groups of subjects corresponding to efficient and inefficient situations, it should be possible to define a set of EHG parameters which properly describes the differences between the two groups.

This paper describes a real-time monitoring device developped in order to compute, from these parameters, an "efficiency criterion" representative of the uterine contraction during parturition. This criterion is proved to be very useful in front of several specific clinical situations further described.

SIGNAL PROCESSING

The temporal and spectral properties of the human uterine electromyogram are analysed into the 0.2 - 3 Hz frequency band, related to two different situations : pregnancy and parturition. A first discriminant analysis (fig. 1) shows the possibility of classifying contractions by means of spectral parameters. In fact, the signal is described by a reduced set of three frequency bands (Total Band : 0.2 - 3 Hz, T, Low Band : 0.2 - 0.45 Hz, L ; High Band : 0.8 - 3 Hz, H) and the duration of the electrical burst (D). Thus, a parameter-set (L/T, H/T, D) is selected, and a discriminant analysis is performed, to compute the best discriminant vector for the two situations.

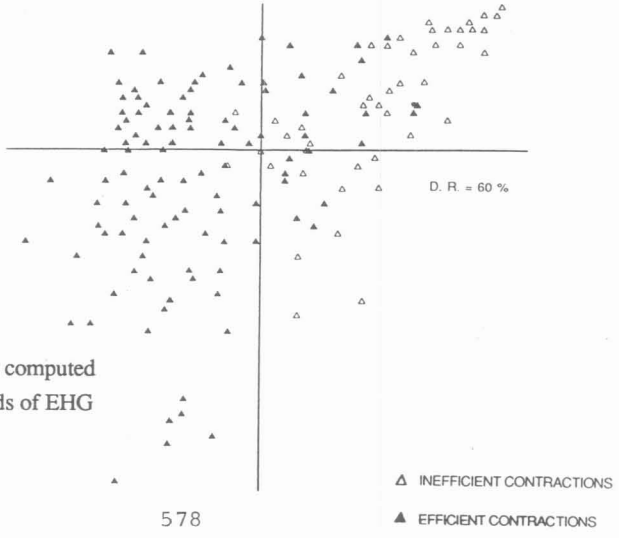

Figure 1 : discriminant plane computed from six frequency bands of EHG

This first discriminant axis is computed as providing the best discrimination between these two classes. Thereby, it provides a way of quantifying the contraction efficiency : for each contraction, an "efficiency criterion" is computed as the projection of the parameter values onto the first discriminant vector (MARQUE and al. [1986]). The real-time computation of this criterion gives an on-line evaluation of contraction efficiency evolution during labor (fig. 2).

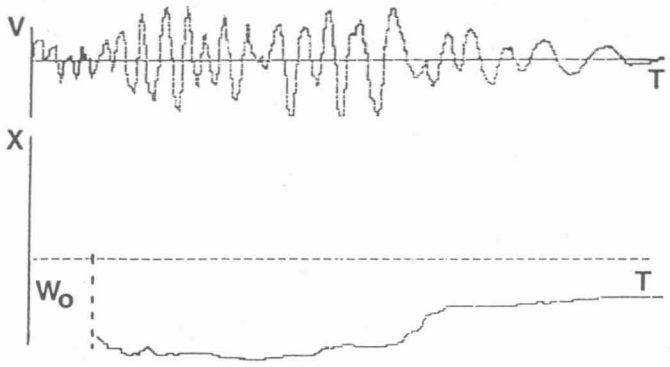

Figure 2 : contraction efficiency criterion . Upper tracing corresponds to the temporal EHG signal. Lower tracing represents the criterion value : W0 gives a first estimate and updating is performed for each new acquired value.

MONITORING DEVICE

A monitoring system has been developped which includes all the hardware an software needed for the on-line monitoring of contraction efficiency : EHG recording and conditionning, processing software and X/T recorder.Processing includes all the necessary steps for real-time monitoring : signal digitization, electrical burst detection, computation of the efficiency criterion, on-line graphical output management.

The computation of the "efficiency criterion" involves the following steps :

- Initialization : after detection of the onset of a burst, the spectral parameters are initialized from a reduced time window (5 seconds). At the end of this window, the parameters are projected onto the discriminant axis giving a first criterion evaluation.
- Updating : each new acquired point modifies the parameter values ; their projection updates the criterion until the end of the burst, providing the evolution of the "efficiency criterion" along the burst duration.
- Final value : at the end of the burst, the final value of the criterion is related to the whole contraction.

A microcomputer-based monitoring device was developped and tested. It includes all necessary electronics for signal amplification and filtering, and a microcomputer system which is in charge of criterion computation and output management (figure 3).

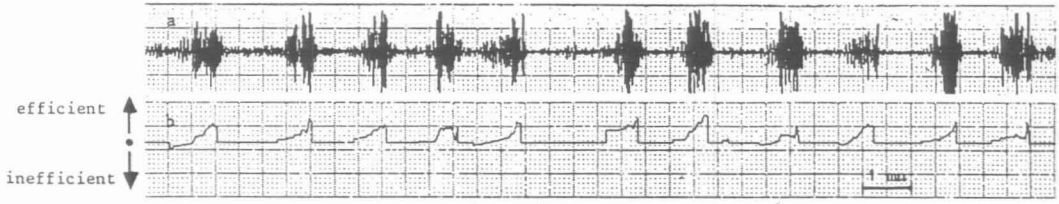

Figure 3 : an example of monitoring device output with filtered EHG signal (a) and criterion value (b)

SOME EXAMPLES OF APPLICATION

- Inefficiency detection

Figure 4 shows the criterion evolution computed from a signal when recorded during a failed induced labour. The induction by ocytocin infusion failed, in spite of frequent enough but inefficient contractions. In this case, the criterion evolves within the inefficient area (below the dashed line).

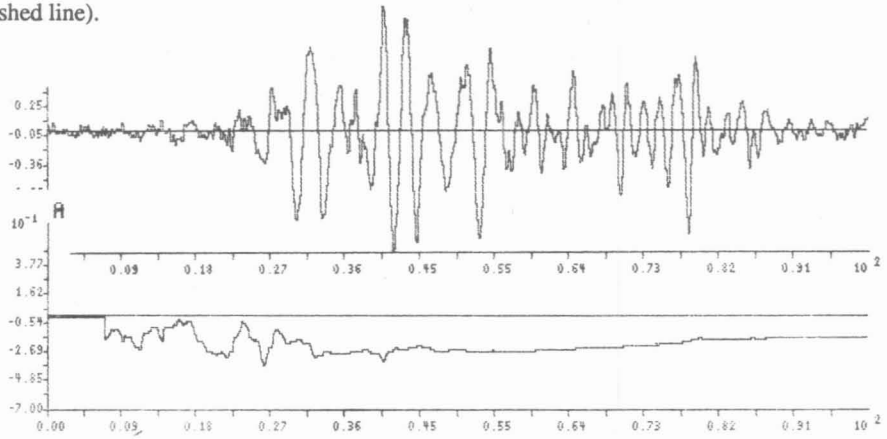

Figure 4 : results from a failed induced labor : criterion remains under the "efficiency" line

- efficiency evolution

Figure 5 shows the evolution of a criterion computed during two failed induced labour attempts (a and b) and during the parturition recording obtained from the same woman. These

supplementary cases, typical of each class, are well classified by means of this criterion. Furthermore, as the signals are recorded from the same woman, these results prove that the criterion is able to follow the physiological evolution of the contractility between efficient and inefficient contractions.

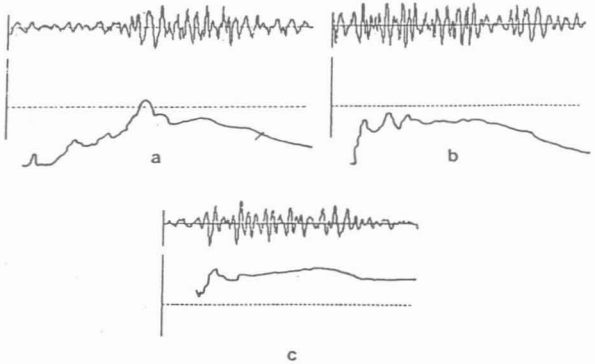

Figure 5 : recordings from the same woman during two failed induced labor attempts (A and B), and delivery (C)

-pregnancy monitoring

Figure 6 shows the criterion evolution computed from recording obtained at the 31st week of pregnancy and related to a preterm labour risk. The criterion remains within the efficient area, thus confirming the small cervical dilatation which was observed for this woman.

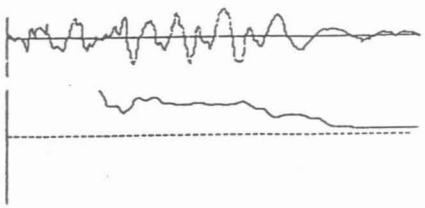

Figure 6 : signal related to a preterm labor risk

CONCLUSION

The abdominal EHG provides an efficient method of measuring uterine activity. The defined criterion was shown to be representative of the contraction efficiency. Its computation is implemented in a stand-alone microcomputer system which offers real time monitoring of the uterine activity efficiency. This provides a new powerful information which will be available for obstetrical monitoring practice.

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