Electromyographic observations on the human cervix during labor

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The activity of smooth muscles in the cervix is one of the relevant factors for its dilatation during labor, but in humans it has not yet been sufficiently studied. Muscular activity may be observed by measuring electromyographic phenomena. In 60 parturient women of different parity and with various degrees of cervical ripeness at the onset of labor, the cervical electromyographic activity was measured through the entire course of labor in synchronization with uterine pressure measurements and also in 30 cases in synchronization with measurements of the uterine corpus electromyographic activity. The conditions necessary for successful measurements are described. The intensity of the cervical electromyographic activity was found to decrease with the level of cervical ripeness and with parity. When measured in the longitudinal direction, the cervical electromyographic activity resembled that of the uterine corpus, but when picked up from the circular lead, in a few cases of unripe cervices it differed from the electromyographic activity of the uterine corpus. (Am J Obstet Gynecol 1987;156:691-7.)

Key words: Electromyography, cervix in labor

The opinion that the cervix is passive during labor and that its dilatation is due to contraction of the uterine corpus has lately been contested by a number of new findings. The latter pertain to histologic and biochemical changes in the cervix which make possible its efficient dilatation during labor,[1] as well as to the activity of cervical smooth muscles in mammals. The smooth muscles of the ewe's cervix contract vigorously even late in gestation and with the approach of parturition.[2] The cervical and uterine smooth musculatures appear to act independently, possibly reflecting their independent functioning.[2] In humans the factors responsible for efficient cervical dilatation during labor are independent of the factors responsible for efficient uterine contraction.[3]

Material and methods

The study involved 60 parturient women of various parity who were sent to the hospital for induced labor and therefore fulfilled the criteria for programmed labor.[4] In each patient the ripeness of the cervix was estimated according to the Bishop scores; after that an amniotomy was performed, a catheter for measuring intrauterine pressure was inserted, electrodes for detecting the electrical activities of the cervix and uterine corpus were attached, and within 30 minutes an oxytocin solution (Syntocinon) was administered by the drip method in a dose of 6.75 mEq/min. In a few exceptional cases Syntocinon was administered only later in the course of labor. "Partograms" were drawn in all the cases.

In the first 20 labors the detection of the cervical electromyographic activity was unipolar, in the 30 subsequent cases it was bipolar and single-lead (usually in the longitudinal direction), and in the last 10 cases both leads were used, a longitudinal and a circular one. The two-lead configuration is shown in Fig. 1. In 30 labors, a simultaneous bipolar recording of the electrical activity of the uterine corpus was also performed.

Surface Ag-AgCl disc electrodes were used to measure the abdominal uterine corpus electrical activity. They were attached 6 to 7 cm apart above the right or left horn of the uterus, with a reference ground electrode placed between the active electrodes. To obtain the electromyographic activity in the cervix, spiral electrodes, usually used to pick up fetal electromyographic activity, were adapted. These electrodes are standard accessories of the Hewlett-Packard HP 8030A cardiotocographic measuring set. A miniature two-channel differential electromyographic preamplifier was designed to amplify low-amplitude electromyographic potentials with the fixed gain of 1000 and a band width of 0.1 to 5 kHz (3 db). To diminish artifacts caused by body movements during labor, it was fastened to the upper part of a thigh by a belt to permit use of electrode wires that were as short as possible.

Electromyographic signals were further amplified by

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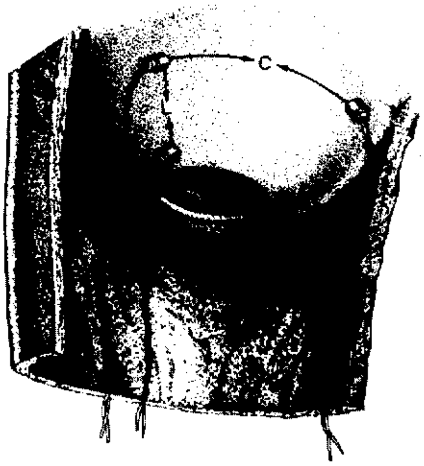

Fig. 1. Position of the spiral electrodes measuring electromyographic activity on the cervix. *L*, Longitudinal lead; *C*, circular lead.

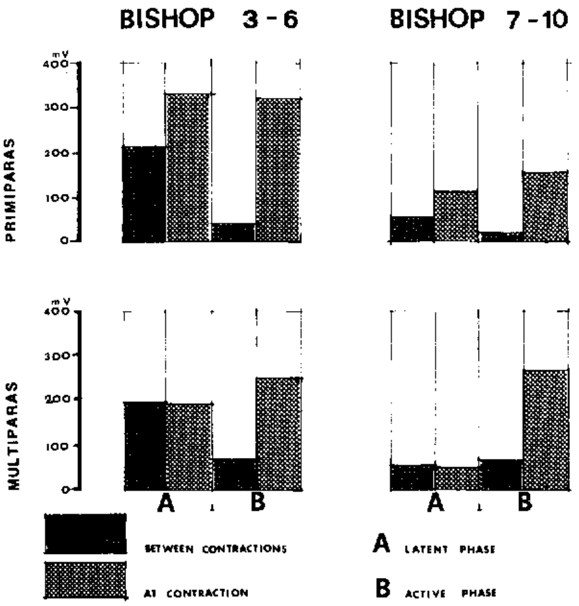

Fig. 2. Mean values of the peak-to-peak amplitude of the electromyographic signal.

a two-channel amplifier with an adjustable gain, an adjustable DC level, and a built-in low-pass filter (5 Hz). Electromyographic potentials were then recorded by a two-channel paper chart recorder which was a part of the above-mentioned cardiotocograph (1 minute = 10 mm). An adequate interface was made which enabled different combinations of simultaneous two-channel registrations.

Intrauterine pressure measurements were performed by means of an open-end saline-filled catheter and a pressure transducer.

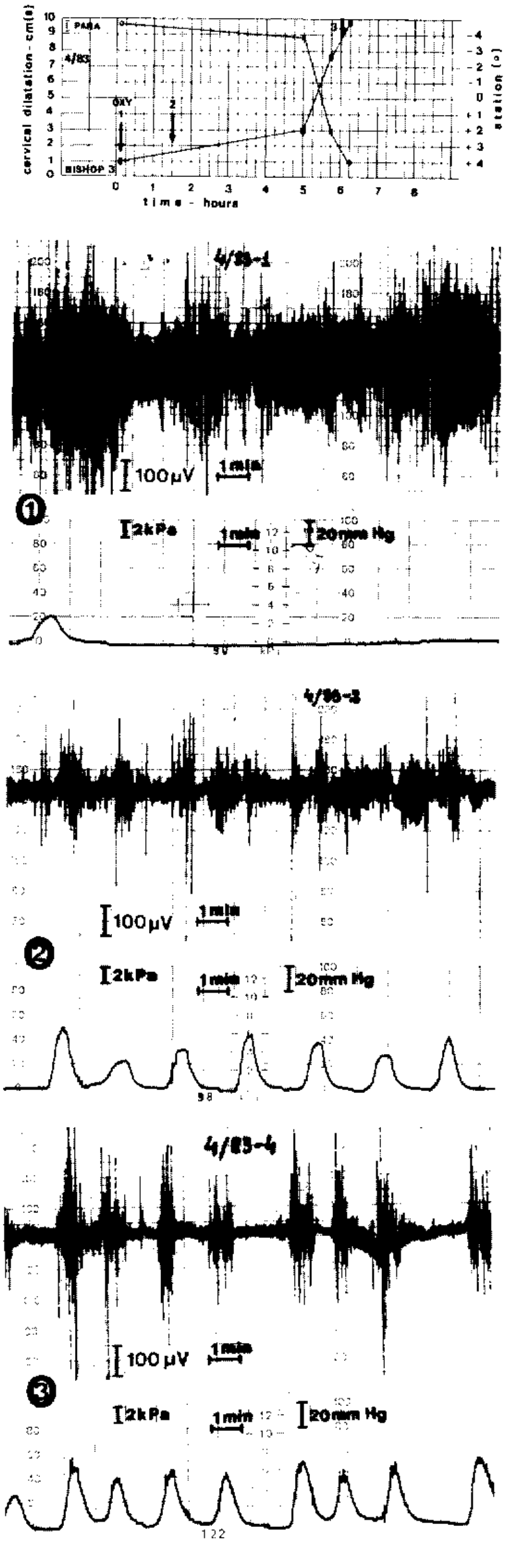

Fig. 3. Partogram, cervical electromyographic activity, and intrauterine pressure in a primiparous patient with unripe cervix. Parts *1*, *2*, and *3* correspond to the events marked in the partogram. For all parts, the upper trace = electromyographic activity and the lower trace = intrauterine pressure ("the basal tone" manually zeroed).

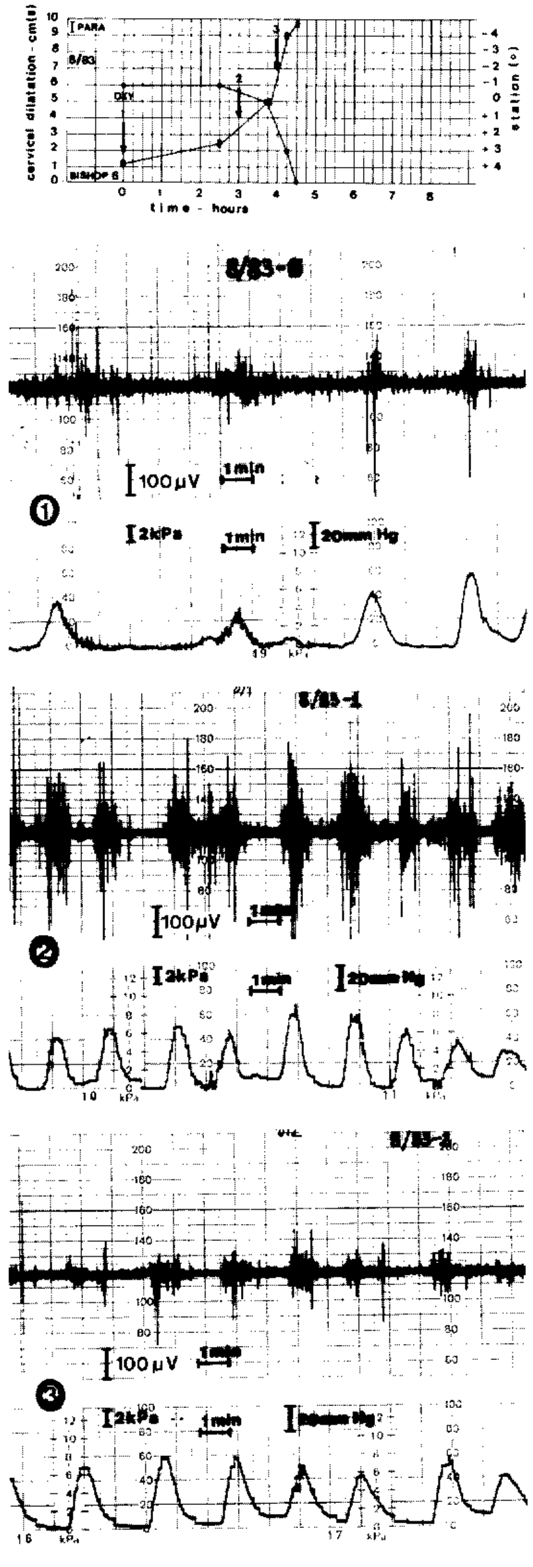

Fig. 4. Partogram, cervical electromyographic activity, and intrauterine pressure of a primiparous patient. Parts *1*, *2*, and *3* correspond to the events marked in the partogram. For all parts, the upper trace = electromyographic activity and the lower trace = intrauterine pressure.

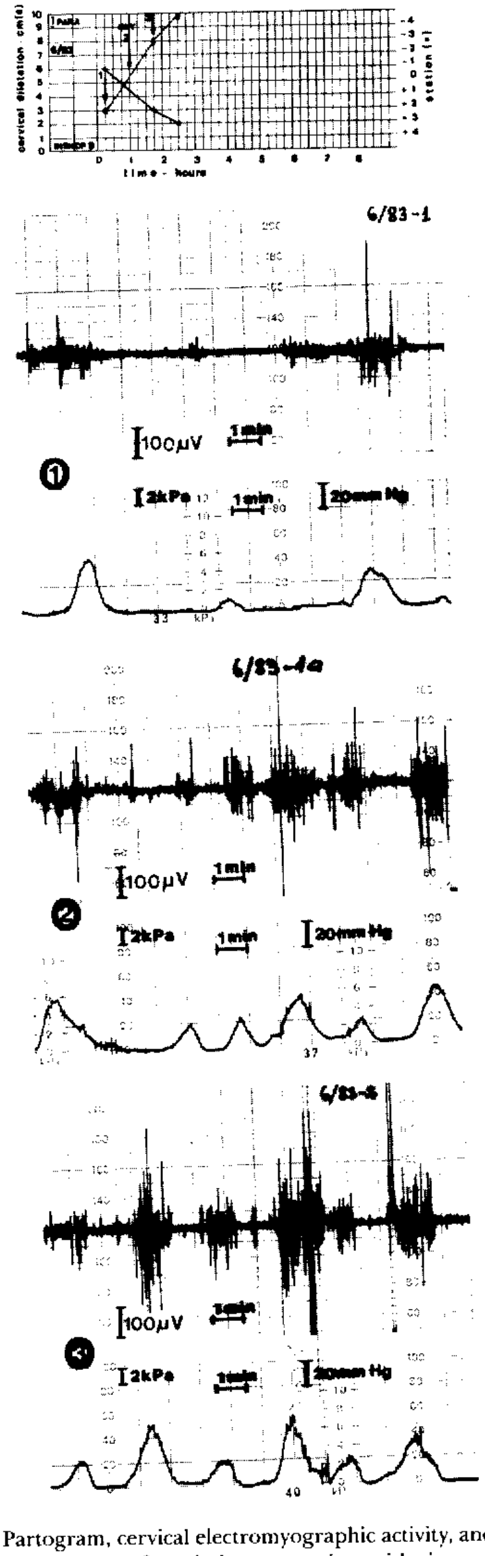

Fig. 5. Partogram, cervical electromyographic activity, and intrauterine pressure of a primiparous patient with ripe cervix. For all parts, the upper trace = electromyographic activity and the lower trace = intrauterine pressure.

Results

Forty-nine appropriate cervical electromyographic recordings were analyzed. They were performed in 28 primiparous women (23 with unripe cervices and 5 with ripe cervices) and in 21 multiparous women (10 with unripe cervices and 11 with ripe cervices). The peak-to-peak amplitude of the strongest burst of electromyographic signal was measured at a uterine contraction and between two contractions in the initial phase of labor—immediately after amniotomy and in the active phase after cervical dilatation of >6 cm. The mean values for each group are presented in Fig. 2.

In an attempt to describe the observed phenomena, typical segments of electromyographic recordings are presented below.

Ripeness of the cervix. The less ripe the cervix, the more intensive is its electrical activity during induced labor immediately after amniotomy (Figs. 3 to 5, *part 1*).

In unripe cervices a strong permanent activity is recorded at the beginning of the latent phase of dilatation, without any noticeable contractions of the uterine corpus (Fig. 3, *part 1*). This activity is subsequently grouped into increasingly pronounced bursts, which are usually synchronized with uterine contractions, but occasionally they also appear between two contractions (Fig. 3, *part 2*). In this period the activity occurring between two contractions is stronger than later in the active phase of dilatation. In riper cervices the initial activity is smaller and grouped into bursts, which occur in synchronization with uterine contractions but occasionally somewhat earlier or later (Figs. 4 and 5, *part 1*). In the active phase of cervical dilatation the activity appears to be grouped in bursts, usually in synchronization with uterine contractions and persisting throughout a contraction. The intensity changes in the course of labor. These changes are not always correlated to the intensity of uterine contractions (Fig. 4, *parts 2* and *3*). The activity, which is ungrouped at the onset of labor, groups and intensifies after administration of the oxytocin preparation. Weak electrical activity associated with infrequent contractions (Fig. 5, *part 1*) increases immediately after administration of oxytocin, and the frequency of contractions increases (Fig. 5, *parts 2* and *3*).

Parity. In principle, the intensity of the cervical electrical activity decreases with parity. Even in a patient who is para 2 with an extremely unripe cervix, electrical activity was observed similar to that found in primiparous patients with unripe cervices. In most cases, however, in secundiparous patients the electrical activity of the cervix bears more resemblance to that characteristic of primiparous women with ripe cervices (Fig. 5), although the cervical dilatation may be slower than in primiparous women with ripe cervices. In triparous and multiparous women the activity is smaller. As a rule, the amplitudes of individual bursts in multiparous women are much smaller. This type of minimal activity is exemplified here by the case of a triparous patient with a cerclage performed during pregnancy because of cervical insufficiency (Fig. 6). After oxytocin had been administered, uterine contractions became more frequent and stronger (Fig. 6, *parts 2* and *3*). The electrical activity appeared to be partly grouped in bursts of small amplitudes. The bursts occurred simultaneously with contractions as well as between two contractions, mostly with a nonuniform waveform and sequence, throughout the labor.

Electromyographic activity of the cervix and uterine corpus. The electromyographic activity of the uterine corpus was observed and compared to the electromyographic activity of the cervix. Because of the different types of measuring techniques implemented, the amplitude proportions between the two groups of results are of course only relative. The cervical electromyographic detection was unipolar and bipolar. After amniotomy the electrical activity in unripe cervices is usually greater than that in the corpus, whereas in the case of ripe cervices the situation is reversed. Later during labor, especially in the active phase of dilatation, the proportion between the two changes independently of the intensity of contractions. In the final phase of dilatation the intensity of electromyographic activity is usually smaller in the cervix than in the corpus (Fig. 7, *part b*). The cervical and uterine corpus electromyographic activities occur in groups of bursts, which are in most cases synchronized both with each other and with uterine contractions. In a few cases, however, the distribution of bursts along the time scale in the cervix is entirely different from that in the corpus (Fig. 7, *part a*).

Two-lead detection of the cervical electromyographic activity. The recording of the cervical electromyographic activity measured longitudinally and circularly are in most cases similar. However, in a few cases the electromyographic activity detected from the two leads differs, for example, in a primiparous woman with unripe cervix, Bishop score of 3 (Fig. 8). The differences are significant, especially in the latent phase of cervical dilatation (Fig. 8, *parts a* and *b*), whereas in the active phase of dilatation they diminish (Fig. 8, *parts c* and *d*). Immediately after amniotomy (Fig. 8, *part a*) the longitudinal activity is minimal. The circularly measured activity is stronger and is manifested as bursts of shorter or longer duration. After oxytocin has been administered (Fig. 8, *part b*), the longitudinal electromyographic activity intensifies. The increase is even greater in the circular direction. It is manifested in

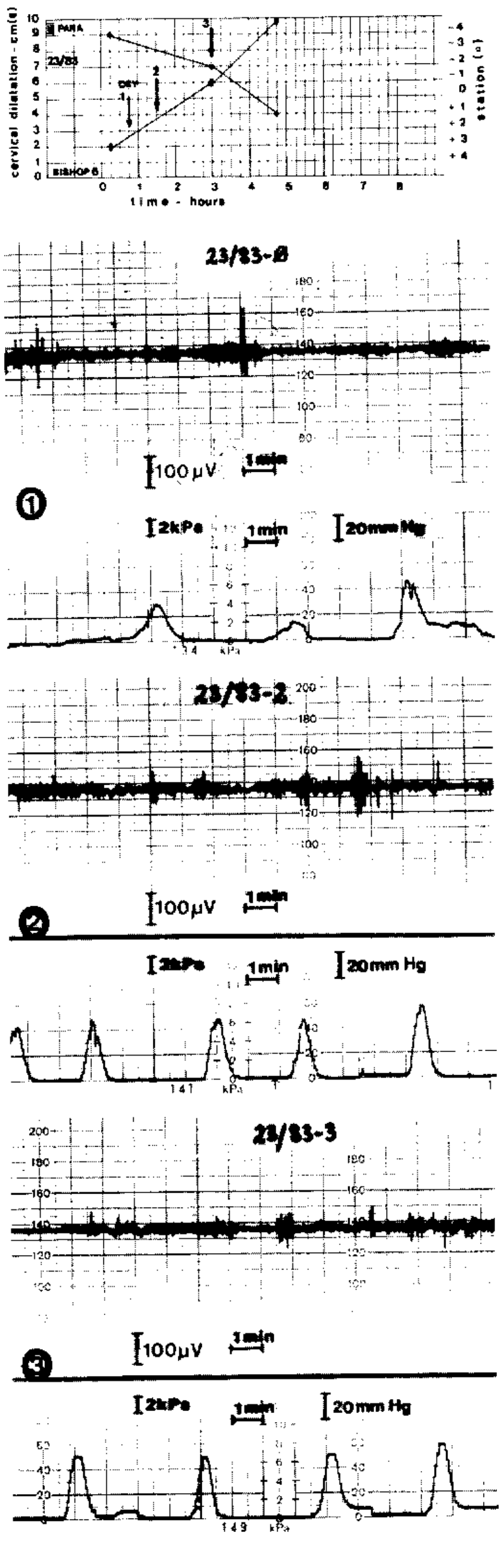

Fig. 6. Partogram, cervical electromyographic activity, and intrauterine pressure of a multiparous patient. Parts *1*, *2*, and *3* correspond to the events marked in the partogram. For all parts, the upper trace = electromyographic activity and the lower trace = intrauterine pressure.

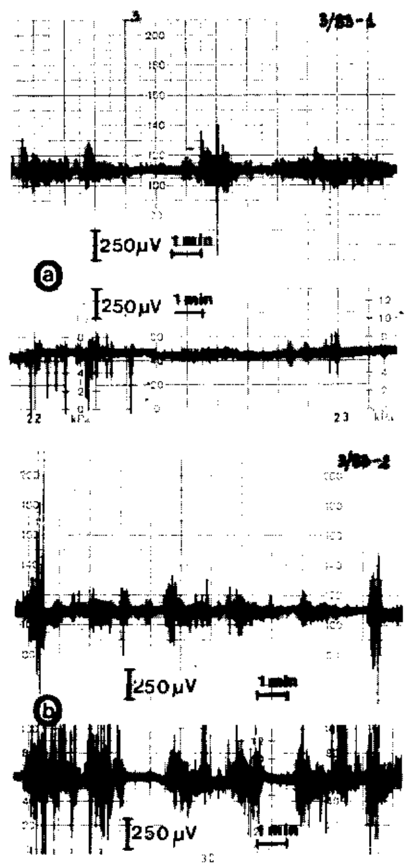

Fig. 7. Comparison of cervical and uterine corpus electromyographic activity measured at the beginning *(a)* and in the middle *(b))* of cervical dilatation in a primiparous patient. The upper trace = electromyographic activity of the cervix and the lower trace = electromyographic activity of the uterine corpus.

different shapes. The activity measured from both leads rapidly increases at the beginning of the active phase of dilatation (Fig. 8, *part c*). The longitudinal activity is relatively well grouped and synchronized with uterine contractions. The circular activity, however, is less well grouped. In the final phase of dilatation (Fig. 8, *part d*) a decrease in both activities is evident, particularly in the circular direction. At this stage the similarity and synchronization between the two activities is evident.

Comment

Adequate cervical dilatation is an important factor for a successful course of labor. The results of the measurements of the cervical electromyographic activity during labor confirm that also in the human the cervix is not just a passive part of the uterus but that its muscles also actively contract.

The results obtained so far primarily confirm the presence of electromyographic activity in the cervix

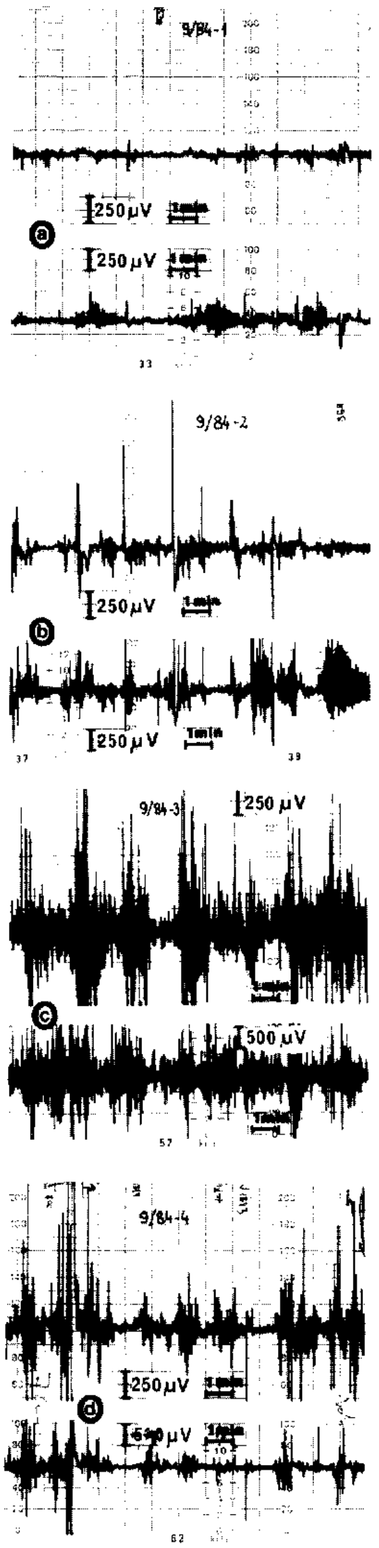

Fig. 8. Comparison of the cervical electromyographic activity measured from the longitudinal lead *(upper trace)* and from the circular lead *(lower trace)*. Part *a* = soon after amniotomy; part *b* = after oxytocin infusion; part *c* = at the 3 cm cervical dilatation; part *d* = final phase of dilatation.

during labor and establish the relevant conditions that have to be fulfilled to achieve efficient and high-quality recordings of this activity. They also suggest that this electromyographic activity appears in two directions, longitudinally and circularly.

The spiral electrodes used in our study to detect the cervical electromyographic activity served our needs well. It is important that they are firmly fixed in the tissue, which of course requires a certain amount of experience. In our first attempts the electromyographic recordings tended to be unreliable and of poor quality, especially toward the end of labor when the women grew restless and artifacts occurred because of movement of the electrodes in the tissues.

Another parameter tested in our investigation was the type of detection, which may be unipolar or bipolar. When unipolar detection was used, far more artifacts were found in the recordings. That is understandable, since such detection picks up the electrical potentials between the measuring electrode and the reference one and covers the potentials generated not only by the cervical muscles but also by all the structures between the two electrodes.

On the basis of the above findings resulting from our preliminary measurements, it was finally decided to use bipolar detection in our further work, since it yields the electrical activity between the two active electrodes inserted in the cervix.

At the initial stage of bipolar measurements of the cervical electromyographic activity, little attention was paid to positioning of the electrodes in terms of discriminating the electrical activity in the respective longitudinal and circular direction. As the difference between the electromyographic activity of the uterine corpus and that of the cervix was noticed, however, it led to the conclusion there might be differences in the electrical activity resulting from the use of different leads as well as from the activity of differently positioned muscle fibers (in the longitudinal and circular direction, respectively).

It was found that, in addition to the regular activity in the longitudinal direction, another, different activity in the circular direction occurs as well.

Because of the above-described course of our investigation, in most of our experimental cases the electrical activity of the longitudinal fibers of smooth cervical muscles was recorded. Their activity resembles that of the uterine corpus. This fact leads to the conclusion that these fibers may be excited by stimuli spreading downward from the corpus. The active contraction of the longitudinal fibers probably helps to shorten, open, and retract the cervix.

Our observations of the longitudinal electromyographic activity in the cervix agree with the findings of some other authors[3] regarding the activity of smooth muscles in the uterine corpus: initially it is more nonuniform, and subsequently it groups into so-called bursts. The difference between the uterine corpus and the cervix activity exists in the fact that the electromyographic activity in the corpus normally anticipates the increase of the intrauterine pressure, whereas in the cervix it appears at the onset of contractions and persists throughout an entire contraction. The intensity of this activity varies in the course of labor quite independently of the intensity of the electromyographic activity of the uterine corpus and of the intensity of contractions. We therefore believe it is partly independent of the uterine corpus.

Particularly interesting is the circular electrical activity in the cervix, measured with the circular lead. This activity is entirely different from that found when recording from the longitudinal lead. It usually occurs in unripe cervices and in primiparous women at the beginning of labor and probably represents the circular muscle fiber activity. At present it can only be said that in all probability this activity does not exist in every woman, but that it is very important for the cervical tonus at the beginning of labor and that later it hinders effective dilatation of the cervical canal.

Visual evaluation of recorded electromyographic activity without more subtle subsequent analyses does not permit more precise description of the electrical phenomena in the cervix during labor. Recent advances in computer analyses of bioelectrical signals make their quantitative explanation possible. Spectral analysis has been implemented for this purpose, and the changes in typical frequencies in the power density spectral function of the cervical electromyographic signal were studied. The results are encouraging in helping to differentiate the contribution of the two types of muscle fibers in the cervix to its efficient dilatation during labor. It is hoped that we will be able to identify the differences between the electromyographic activity of the cervix and that of the uterine corpus.

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