



Article

## External four-channel tocography during delivery

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Received 11 February 1994; revision received 2 May 1994; accepted 2 May 1994

### Abstract

**Objective:** A four-channel tocographic technique was developed in order to improve present knowledge of spatial uterine motility. **Method:** Fifty-four women were monitored during labor. Four pressure transducers were attached in a square around the umbilicus. **Results:** The origin of uterine contractions was generally determined to be in the upper right segment of the uterus. The rate of operative deliveries was decreased in the case of predominant upper right origin of labor. Most of the contractions with clear propagation patterns originated on the upper right side, continued to the left and then spread to the lower right part of the uterus. The highest relative intensity was also measured on the upper right side. **Conclusion:** Predominant upper right origin of labor may be important for unassisted or spontaneous delivery.

**Keywords:** External tocography; Four-channel tocography; Labor; Delivery

### 1. Introduction

The development of four-channel tocography was based on the idea that information on uterine contractions would probably be improved by simultaneous, temporal and spatial registration of the external pressure at multiple sites of the abdomen instead of at one single point.

Almost 100 years ago Schaeffer reported the first experiments with non-invasive monitoring of labor [1]. However, it was only in the 1950s that Caldeyro-Barcia and co-workers published clinic-

ally relevant systematic studies on uterine motility [2]. At that time external pressure transducers were quite insensitive and therefore invasive methods had to be used [3].

The aim of the present study was to identify the spatial course of labor by four-channel tocography and its possible relation to labor progress.

### 2. Subjects and methods

#### 2.1. Patients

Study subjects comprised parturients with a dilation of the cervical canal of at least 2 cm, vertex presentation of the fetus and normal labor. All subjects had received verbal information about

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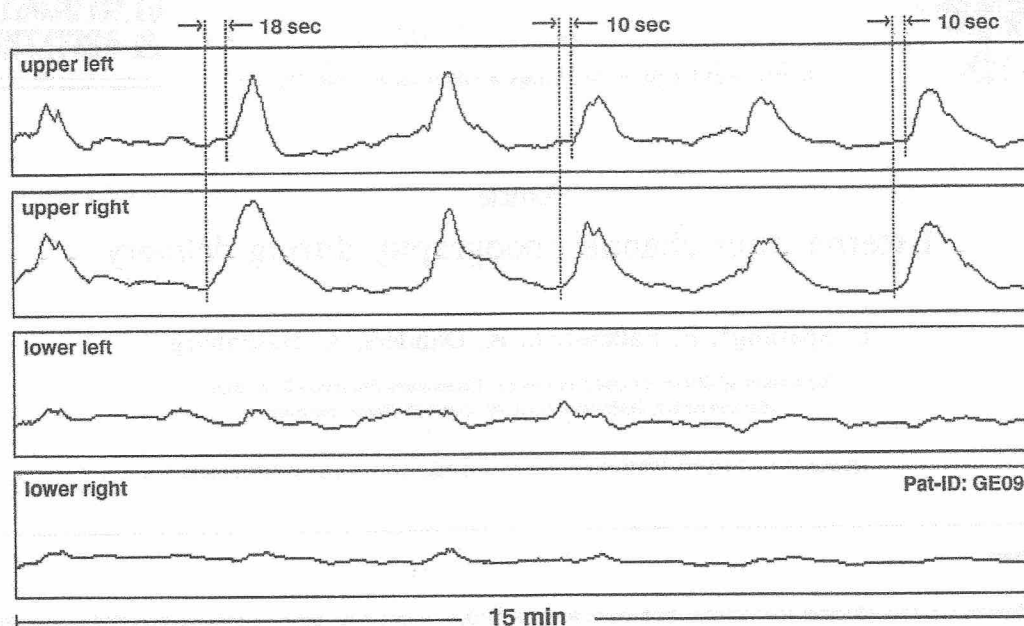


Fig. 1. Computer plot of a four-channel tocographic recording (section of 15 min).

the study and had given their informed consent. Patients who had received tocolytic or labor-promoting drugs were excluded from the study.

### 2.2. Instrumentation

Four external tocometric transducers were used. The purpose-built sensors have similar signal characteristics to routinely used and commercially available transducers. However, the use of piezoelectric pressure-sensitive elements allowed a particularly flat and light construction especially suitable for the intended purpose.

After signal conditioning and four-channel analog-to-digital conversion the data were stored on floppy disks as 8-bit samples at a rate of 4.5 Hz per channel using a bedside-installed portable computer (Zenith 181, Zenith Data Systems Corporation, St. Joseph, MI, USA).

### 2.3. Management protocol

The four tocometric transducers were brought to their positions, each pair a handbreadth dis-

tance above/below the umbilicus and right/left, respectively. These locations were referred to as 'upper right', 'upper left', 'lower right' or 'lower left'. The transducers were fixed on the abdomen by an elastic textile tube. No additional transducers were attached. The fetal heart rate was monitored by a fetal scalp electrode. Measurements were carried out in the supine position if tolerated by the patient, otherwise in a more lateral position. Measurements were terminated after about 30 min and stopped completely at the beginning of the final stage of labor. The localization of the placenta was not documented. The obstetrician who decided to perform a cesarean section or a vacuum extraction had no possibility of examining the recordings.

### 2.4. Study evaluation

After the last measurement the signals of the four transducers were plotted in parallel from the computer-stored data (Fig. 1). Taking each of

Table 1  
History and obstetric factors

|                         |                               |
|-------------------------|-------------------------------|
| Maternal age (years)    | 26 (20-38) (median, range)    |
| Gestational age (weeks) | 40 (34-42) (median, range)    |
| Parity                  |                               |
| 0                       | <i>n</i> = 28                 |
| 1                       | <i>n</i> = 17                 |
| 2                       | <i>n</i> = 6                  |
| 3                       | <i>n</i> = 3                  |
| Dilatation (cm)         |                               |
| 2-3                     | <i>n</i> = 20                 |
| 5-6                     | <i>n</i> = 16                 |
| >6                      | <i>n</i> = 18                 |
| Delivery                |                               |
| Spontaneous             | <i>n</i> = 45                 |
| Cesarian section        | <i>n</i> = 7                  |
| Vacuum extraction       | <i>n</i> = 2                  |
|                         | } Indicated by stagnant labor |

these plots, the time differences in the onset of contraction patterns between the transducers were determined by visual analysis of the chart and transformed into a chronological sequence which was noted as the 'propagation of labor'. The location relating to the first rank in this sequence was noted as the 'origin of labor'. For each recording the particular transducer site which appeared as the origin of labor in all or the majority of contractions was identified as the 'predominant origin of labor'. The amplitudes of contraction patterns were measured to estimate their relative intensity. Furthermore, the type of shape was determined for each contraction pattern (I, flat increase/steep decrease; II, symmetrical shape; III, steep increase/flat decrease; IV, double peak). Types I-III were defined according to Baumgarten [4]. Within one measurement the 'predominant type of contraction' was determined as that type which oc-

Table 2  
Origin of labor (transducer site)

|                           |           |
|---------------------------|-----------|
| Total no. of contractions | 593       |
| Upper right               | 256 (43%) |
| Upper left                | 187 (31%) |
| Lower right               | 34 (6%)   |
| Lower left                | 23 (4%)   |
| Origin not determinable   | 93 (16%)  |

curred most often among the recorded patterns characterized as the origin of labor.

### 2.5. Statistics

Categorical data (relative frequencies) were tested with Fisher's exact test. Differences in central tendencies of unpaired data were tested with the Mann-Whitney-Wilcoxon *U*-test. Statistical significance was accepted at a *P*-value of <0.05.

### 3. Results

Fifty-four measurements were carried out with recording times between 24 and 37 min (median 30 min). Table 1 summarizes the historical and obstetrical data of the patients.

#### 3.1. Origin of labor

From a total of 593 contraction patterns, 500 (84%) had a clearly determinable origin. Most of the contractions began in the upper right segment of the uterus (*P* < 0.001). The upper positions dominated over the lower, and the right positions over the left (Table 2). Two of 30 women with predominant upper right origin of labor had to be delivered operatively compared with seven of 24 with predominance at other sites (7% vs. 29%, *P* < 0.05).

#### 3.2. Propagation of labor

From 193 patterns (33%) it was possible to determine a strict chronological sequence in the contraction onset of at least three transducer signals. Most frequently (27%) encountered were contractions that started at the upper right side,

Table 3  
Propagation of labor (in order of frequency)

|  |            |
|--|------------|
| Upper right -- upper left -- lower right | 51 (27%)   |
| Upper left -- upper right -- lower right | 35 (18%)   |
| Upper left -- upper right -- lower left  | 26 (14%)   |
| Upper right -- upper left -- lower left  | 20 (10%)   |
| Upper right -- lower right -- upper left | 18 (9%)    |
| Upper right -- lower left -- upper left  | 12 (6%)    |
| Other                                    | 31 (16%)   |
| Total                                    | 193 (100%) |

Table 4  
Type of labor vs. mode of delivery

| Predominant type of labor | Mode of delivery |                  |         | Total |
|---------------------------|------------------|------------------|---------|-------|
|                           | Spontaneous      | Cesarean section | Vacuum  |       |
| I                         | 5 (63%)          | 2 (25%)          | 1 (12%) | 8     |
| III                       | 38 (86%)         | 5 (12%)          | 1 (2%)  | 44    |

continued with the excitation of the upper left and went on to the lower right side (Table 3). No correlation between particular propagation patterns and the modes of delivery was found.

### 3.3. Labor intensity

The highest relative labor intensity was measured at the upper right side, independent of the origin of contractions ( $P < 0.001$ ). Since these intensity data are not comparable interindividually, no results are available in context with the mode of delivery.

### 3.4. Type of contraction

Fifty-nine percent of all evaluable contraction signals were of type III (steep increase/flat decrease), 29% of type I (flat increase/steep decrease), 10% of type II (symmetrical) and 2% of type IV (double peak). Types I and III predominated. The frequency of type-I predominance was higher in operative deliveries ( $P = \text{NS}$ , Table 4).

## 4. Discussion

In monitoring changes in the same tissue below the transducer our sensors showed the same characteristics as all commercially available transducers for external labor registration. Because of the different thicknesses and compliance of the abdominal wall no statement regarding absolute labor intensity can be made. However an association of the course of the four signals according to the characteristics, timing and relative amplitude was possible.

Contractions originating at sites other than the upper right region were correlated with an increased rate of 'stagnant labor' with subsequent cesarian section or vacuum extraction.

Only a relatively coarse summary can be made of all the reasons for stagnant labor under one diagnosis. The accompanying diagnoses were relative cephalo-pelvic disproportion and inlet disproportion ( $n = 1$ ), posterior parietal bone presentation ( $n = 1$ ), rupture of the uterus ( $n = 1$ ), and previous cesarian section ( $n = 2$ ). Although the obstetrical problems of this group were caused by different mechanisms, the contractions did not result in spontaneous delivery. No operative delivery was performed because of fetal distress. Caldeyro-Barcia et al. found a negative influence of uncoordinated uterine motility on parturition [2]. This may be discussed in the same context. The described method is suitable for the registration of labor propagation during parturition.

Typical patterns of contractions with labor origin in the upper right or upper left uterine segment as observed by Reynolds [5] and confirmed by Caldeyro-Barcia et al. [2] and Alvarez and Caldeyro-Barcia [3], are clearly representable with this simple non-invasive technique. The predominance of the upper right segment is also reflected in the distribution of relative labor intensities as shown in our results. This suggests a faster depolarization of smooth muscle cells in this segment, although neither histological nor electrophysiological methods have yet proved the existence of any pacemaker-like substrate in this area [6].

The origin of labor seems to be more important for labor efficiency than its further propagation. References to the clinical significance of a classification of the right or left side of the uterus could not be found in the literature. Caldeyro-Barcia et al. described a 'triple descendant gradient': (1) propagation of the contraction downward; (2) decrease in duration of the contraction with distance from the pacemaker; and (3) downward reduction of the

intensity of the contraction [2]. According to our results a classification of the uterus not only into the upper and lower segments but also into the right and left sides seems useful, since with an upper right dominance good progress of delivery can be expected.

In addition the present study confirmed that the type of contraction is correlated to the course of delivery [4]. Type-III labor (steep increase/flat decrease) predominated in undisturbed deliveries, although this tendency was not statistically significant, probably due to the small number of investigated cases. An association of the signals with intrauterine pressure would be useful, and corresponding measurements are in progress.

The observations described above appear to stress the importance of the right upper part of the uterus as the starting point of obstetrically efficient, physiological labor. More research on multichannel tocography is necessary to reveal the influences of additional obstetric factors, e.g. localization of the placenta, presentation of the fetus, stage of labor, etc. Further studies would also be important to confirm the described results in a larger group of subjects. A computer-assisted on-line analysis would

improve the use of multichannel tocographic signals during delivery and may be of future help in making therapeutic decisions.

#### Acknowledgment

This study was supported by the Deutsche Forschungsgemeinschaft DFG (SP 213/2).

#### References

- [1] Schaeffer O: Experimentelle Untersuchungen über die Wehentätigkeit des menschlichen Uterus. Hirschwald, Berlin, 1896.
- [2] Caldeyro-Barcia R, Alvarez H, Reynolds SRM: A better understanding of uterine contractility through simultaneous recording with an internal and a seven channel external method. *Surg Gynecol Obstet* 91: 641, 1950.
- [3] Alvarez H, Caldeyro-Barcia R: The normal and abnormal contractile waves of the uterus during labor. *Gynaekologia* 138: 190, 1954.
- [4] Baumgarten K. Die Beeinflussung der Uterusmotilität. Hollinek, Vienna, 1967.
- [5] Reynolds SRM: Physiology of the Uterus, 2nd edn. Harper, New York, 1949.
- [6] Shulman J, Romney S: Variability of uterine contractions in normal human parturition. *Obstet Gynecol* 36: 215, 1970.