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Measurement of head compression during labor: Preliminary results

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1 Introduction

During uterine contractions, the presenting part of the fetus is pushed downward towards the narrow pelvic outlet and pressed against the wall of the birth canal, thus being subjected to the resistance of the maternal tissue. Strong head compression, however, is assumed to cause serious brain damage of the child mainly by two pathogenetic mechanisms. One factor may be the elevation of the intracranial pressure which reduces the cerebral perfusion leading to ischemia, edema and hemorrhage [6, 8]. The other factor can be molding of the fetal skull resulting in cerebral trauma with rupture of blood vessels.

In previous studies, several types of apparatus have been designed to measure the compression and traction forces applied on the baby's head in deliveries assisted by forceps or vacuum extraction [2, 5, 7]. Also some methods have been described which measure the pressure on one side of the fetal head during spontaneous labor [1, 4, 5, 9].

The objective of this study is to quantify the pressure to which the fetal head is exposed during delivery.

2 Methods

Our instrument was designed to measure head compression continuously in a simple and reliable manner during the second stage of labor when the greatest pressure on the brain can be expected because of the combined effect of the mother's bearing-down efforts added to the uterine contractions. Continuous recordings of these forces enables any changes occuring during labor to be analysed.

Our instrument consists of two pressure transducers which function according to the strain gage principle and are mounted on the outer side of the two mobile ends of a metal bow. The whole instrument is encapsulated in a heat-shrinkable tube designed to prevent fetal or maternal injury or damage to the transducer.

The signals of our compression transducer showed a linear response to the force acting on it. For comparison with the intra-amniotic pressure, the signals were calibrated against units of pressure, i.e. kPa or mmHg.

When the cervix was almost fully dilated the device was placed transvaginally against the fetal head so that each of the ends of the bow are positioned on either side of the head between the parietal bone and the maternal tissue of the birth canal. The amplified electric signals of the instrument were recorded on a four-channel-recorder at a paper speed of one centimeter per minute together with the tracings from the cardiotocograph. The signals were also stored in a desk-top computer in intervals of one second for further calculations and statistical analysis. In addition, data about the position and station of the fetal head, maternal position, oxytocin infusion, tocolysis etc. were simultaneously noted.

Figure 1 shows a section of a recording produced by the computer. The intrauterine pressure was measured by a fluid-filled catheter inside the amniotic cavity, the fetal heart rate was continuously obtained via a scalp electrode. For a given period of labor of each patient, the mean maximum amplitude of the intra-amniotic and head pressure, respectively, was calculated by dividing the sum of the pressure peaks of all contractions by the number of contractions. Furthermore, the

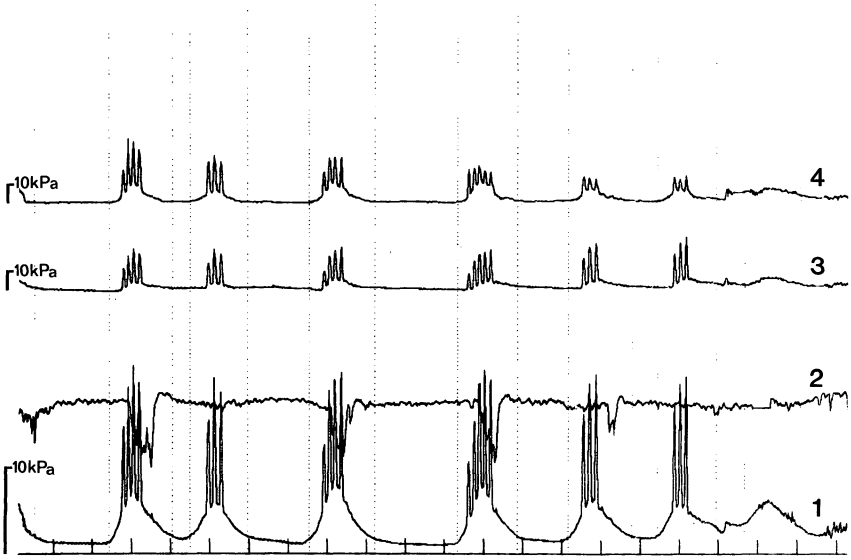

Figure 1. Section of simultaneous original tracings of amniotic pressure (1), fetal heart rate (2) and pressures on the left (3) and right (4) parietal region of the fetal head.

mean pressure during uterine contraction in the amniotic cavity and on the fetal head, respectively, was calculated by dividing the sum of the areas under the pressure curve during contractions by the duration of all contractions. Accordingly, the mean pressures between the uterine contractions were obtained. All women had given their prior consent for the investigation.

3 Results

Data from 42 spontaneous occiput-anterior vertex deliveries were analysed. There were 20 primiparae and 22 multiparae whose mean age was 27 years (range: 19–37). Of the women, 13 received epidural analgesia, and 17 had a pundendal block. The duration of the second stage ranged from 2 to 65 minutes (mean: 20), the number of uterine contractions with bearing-down efforts from 2 to 35 (mean: 10). The mean gestational age was 39 weeks (range: 36–41). The average birth weight of the newborns was 3,438 g (2,600–4,450), the mean biparietal diameter measured 9.5 cm (9.0–10.1) and the mean head circumference 35 cm (31–39).

Figure 2 shows the amniotic pressure and head pressure during the last 27 monitored contractions of delivery of a 26-year-old Gravida I giving birth at term to a healthy boy who weighed 3,870 g and who had an Apgar score of 10 at 1 and 5 min., respectively. Values during uterine contractions and during the contraction intervals are depicted. The figures of pressure on the head were calculated by averaging the recordings from both sides of the skull. It can easily be seen that the steady increase of intrauterine pressure readings is parallelled by a rise of the corresponding measurements of head compression. The mean pressure on the head during contraction increases from 7.1 kPa (53.2 mmHg) to 17.9 kPa (134.1 mmHg), the maximum pressure on the head rises from 12.2 kPa (91.3 mmHg) to 53.8 kPa (403.0 mmHg). The corresponding figures for the amniotic pressure are 4.5 kPa (33.7 mmHg), 7.6 kPa (56.9 mmHg) and 12.3 kPa (92.1 mmHg), 17.8 kPa (133.3 mmHg). Figure 3 illustrates the relationship between the amniotic and head pressure of the same case by correlating the maximum values.

Table I summarizes the average values of the calculated measurements of amniotic pressure and fetal head pressure, observed in the 42 deliveries during the period of bearing down and during the last uterine contraction, respectively. In the column on the right-hand side the ratio is also given. Overall, the pressure on the fetal head is about twice that of the intrauterine pressure

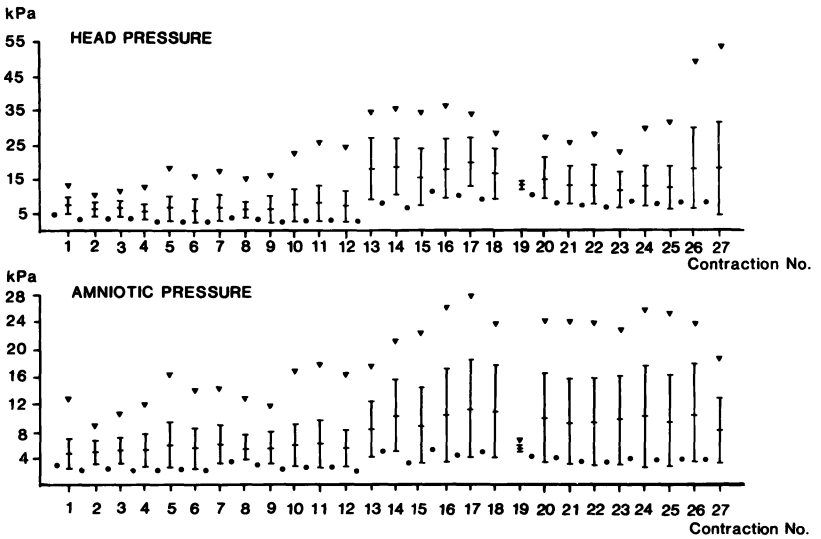

Figure 2. Course of head pressure and amniotic pressure with regard to the monitored number of uterine contraction in the second stage of labor of a primigravida. Mean value ± standard deviation during contraction (I) maximum amplitude during contraction (▼), mean value during the interval between uterine contractions (●).

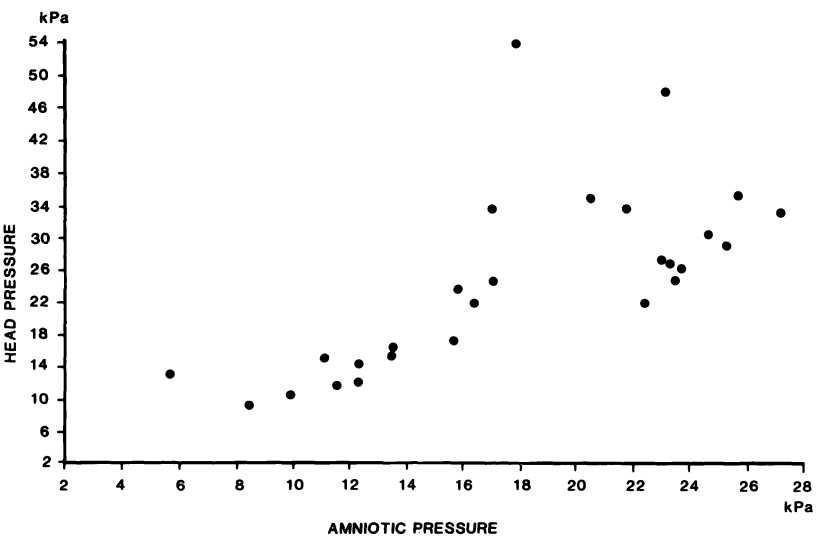

Figure 3. Relationship between the maximum values of head pressure and amniotic pressure in the case shown in figure 2.
(n = 27 contractions).

during uterine contraction. During the interval between the two last contractions, however, a marked elevation of the mean head pressure in comparison to the value in the total bearing-down period can be observed, whereas the corresponding intrauterine pressure remains unchanged. Thus, the ratio of the mean pressures during the contraction interval rises to about three before the last bearing-down effort which succeeds in delivering the fetal head.

Table I. Mean pressures (± standard deviation) on the fetal head and in the amniotic cavity in 42 normal deliveries

Period	Parameter	Mean pressure ± SD in kPa (mmHg)		
		Fetal head	Amniotic cavity	Ratio
Bearing-down	Maximum	31.8 ± 11.0 (238.2 ± 82.4)	18.9 ± 4.3 (141.6 ± 32.2)	1.7
	Mean	13.3 ± 4.8 (99.6 ± 36.0)	8.4 ± 1.6 (62.9 ± 12.0)	1.6
	Basal	5.5 ± 3.7 (41.2 ± 27.7)	2.6 ± 0.9 (19.5 ± 6.7)	2.1
Last contraction	Maximum	47.7 ± 18.8 (357.3 ± 140.8)	20.3 + 5.1 (151.3 ± 38.2)	2.3
	Mean	19.4 ± 8.0 (145.3 ± 59.9)	10.3 ± 2.7 (77.2 ± 20.2)	1.9
	Basal	8.4 ± 5.3 (62.9 ± 39.7)	2.7 ± 1.2 (20.2 ± 9.0)	3.1

Maximum = average peak pressure during uterine contractions
Mean = mean value during uterine contractions
Basal = mean value during the intervals between uterine contractions.

4 Discussion

In all investigations which measure the pressure extended on the fetal head in the birth canal, it is assumed that analysis of the force observed on the surface of the skull, would provide an indirect measure of pressure on intracranial structures. Until now, it has been impossible to get the absolute pressure inside the skull by using non-invasive procedures during labor.

Previous investigations have confirmed the obvious likelihood that the forces acting on the fetal head are not evenly distributed [1, 3]. Thus the values obtained vary significantly according to the location of the transducer on the skull. For practical reasons, we chose the parietal region as the reference area for the measurement of head compression. It can be easily reached and identified by transvaginal palpation when the cervix is fully dilated, thus allowing the transducer to be applied and its position to be controlled more easily. The device is especially designed to be easily fixed on the head during delivery so that the development of the compression forces in different phases of labor and the results from individual patients can be reliably compared. Unlike previous reports [1, 4, 5, 9], we are measuring the compression forces on both sides of the fetal skull. In our opinion, this procedure provides data that are more closely related to the true pressure on the head because the forces acting on corresponding areas of the left and right side of the fetal head are often different. This is due to the complex anatomy of the birth canal which is shaped like a curved tube, bordered partly by the bony pelvis and partly by soft tissue and through which the fetal head must rotate as it descends. A correlation between the intrauterine pressure and pressure on the head is obvious but as can be deduced from the range of points in the graph of figure 3, a more detailed analysis considering for example the station of the fetal head in the birth canal, is necessary before definite conclusions can be drawn.

Our data are in the range found by other investigators [1, 4, 5, 9] (table II). Comparison of the values, however, is limited due to differences in the study population, in the phase of labor, and in the method of calculating the pressure. We also observed a great variation in the pressures on the head between the individual deliveries in our series as can be concluded from the large standard deviations in table I. Although we are therefore prevented from defining the limits of

Table II. Average values (kPa) of amniotic and head pressures during the second stage of labor (review of literature)

Author	n	Amniotic pressure		Head pressure	
		Basal	Maximum	Basal	Maximum
LINDGREN[1]	1960 10	1.3–1.5	14.4–16.1	2.3–10.1	16.9–41.6
MOOLGOAKER[2]	1979 44	–	–	–	47.6–66.2
FURUYA	1981 40[3]	2.8	15.4	4.0	53.9
SVENNINGSEN	1988 24	–	–	–	24.1
REMPEN	1989 42	2.6	18.9	5.5	31.8

Basal = mean pressure during the intervals between the contractions
Maximum = average peak pressure during uterine contractions.
[1,2] The original unit used by the author ([1] mmHg, [2] psi) was converted to kPa
[3] Simultaneous recording of amniotic and head pressure in 15 patients

tolerance of normal pressure on the head during labor, a low pressure on the head might be an indicator of an inadequate maternal bearing-down effort or of weak uterine activity whereas high values may indicate feto-maternal disproportion. During the period of bearing-down, the intrauterine pressure between contractions remained unchanged. The pressure on the fetal head, however, increased in most cases, especially during and before the last uterine contraction, i. e. when the fetal head had usually reached the narrow pelvic outlet. The reason can be found in the greater resistance of both the bony pubic arch and of the stretched soft tissue of the pelvic floor.

We hope that the objective measurement of pressures between the fetal head and the birth canal will elucidate some of the mechanisms of human labor and give further information about the normal strain on the fetus during spontaneous parturition. This will form the basis for further studies of the relationship between birth-related injuries and excessive compression of the fetal head during its passage through the birth canal.

Abstract

To study the pressure to which the fetal head is exposed during the second stage of labor, an instrument was designed to measure continuously the pressure between the presenting part and the birth canal on both sides of the fetal head. Pressure parameters during and between the uterine contractions were calculated from 42 spontaneous vertex deliveries presenting as occiput anterior. During the second stage the overall average of the mean maximum head pressure during uterine contraction was 31.8 ± 11.0 kPa, that of the mean head pressure measured 13.3 ± 4.8 kPa during uterine contraction and 5.5 ± 3.7 kPa during the interval between contractions. The pressure on the fetal head was about twice as high as the amniotic pressure. It increased towards the end of labor.

The objective measurement of fetal head pressure is the prerequisite in the study of the relationship between birth-related injuries and excessive head compression during parturition.

Keywords: Amniotic pressure, fetus, head compression, monitoring, labor.

Zusammenfassung

Messung des Druckes am Kopf sub partu: Vorläufige Ergebnisse

Ziel dieser Studie war es, die Kräfte, die auf den kindlichen Kopf während einer vaginalen Entbindung einwirken, quantitativ zu erfassen. Das Meßinstrument bestand aus einem Metallbügel, auf dessen beiden Enden jeweils ein Transducer montiert wurde. Hiermit war eine kontinuierliche Messung des Druckes zwischen der Parietalregion und der Wand des Geburtskanals in der Austreibungsphase, wo man die größte Belastung erwartet, möglich. Die Signale wurden verstärkt und zusammen mit dem CTG aufgezeichnet und im Computer gespeichert (Abb. 1).

Es wurden 42 Spontangeburten aus vorderer Hinter-

hauptslage ausgewertet. Wir berechneten Parameter wie den mittleren maximalen Druck und den mittleren Druck während einer Wehe bzw. einer Wehenpause für bestimmte Zeitabschnitte bei jeder Entbindung. Es bestand eine deutliche Korrelation zwischen dem intraamnialen Druck und der Kopfkompression (Abb. 2 und 3). Im allgemeinen war der Druck am kindlichen Kopf zweimal so hoch wie der intrauterine Druck (Tab. I). Bei den verschiedenen Entbindungen beobachteten wir jedoch eine große Variation bei den Druckparametern. Im Gegensatz zum intraamnialen Druck nahm der Druck am Kopf im Mittel gegen Ende der Geburt zu. Objektive Messungen der Krafteinwirkungen am kindlichen Kopf tragen dazu bei, den Geburtsmechanismus besser zu verstehen und sind die Voraussetzung, um die Zusammenhänge zwischen geburtsbedingten Verletzungen und exzessiven Druckeinwirkungen am kindlichen Kopf zu untersuchen.

Schlüsselwörter: Fet, Geburt, intraamnialer Druck, Kopfkompression, Überwachung.

Résumé

Mesure de la compression de la tête pendant l'accouchement: Resultats préliminaires

L'objectif de cette étude est de quantifier la pression à laquelle la tête fœtale est soumise pendant l'accouchement par voie basse. Notre instrument consiste en deux sondes placées sur les deux extrémités d'un arc métallique. Il a été mis au point pour mesurer de façon continue la pression entre la région pariétale des deux cotés de la tête fœtale et le canal obstétrical au cours de la seconde partie du travail lorsque on peut s'attendre à la charge la plus lourde en raison des efforts expulsifs de la mère. Les signaux amplifiés sont enregistrés en meme temps que ceux du cardiotocographe et sont stockés dans un ordinateur (figure 1).

L'analyse comporte 42 accouchements spontanés en présentation céphalique antérieure. On a calculé pour une période donnée au cours de chaque accouchement des paramètres tels que la pression maximale moyenne la pression moyenne au cours de la contraction utérine et l'intervale. Une corrélation entre la pression amniotique et céphalique est évidente (figures 2 et 3). Globalement, la pression sur la tête fœtale est environ deux fois plus élevée que la pression intra utérine (tableau 1). Toutefois, on a observé une grande variation des paramètres de la pression entre les accouchements individuels. A l'opposé de la pression amniotique, la pression sur la tête fœtale augmente en moyenne vers la fin du travail. Les mesures objectives de la pression sur la tête fœtale au cours du travail peuvent élucider certains mécanismes du travail humain et représent les préalables à l'étude des relations entre les traumatismes liés à la naissance et une compression excessive de la tête fœtale.

Mots-clés: Compression céphalique, fœtus, pression amniotique, surveillance, travail.

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