Lindgren, Lennart, Acta Obst. et Gynec. Scandinav. *39*, 46, 1960.

From the Department of Obstetrics and Gynæcology (Professor A. Ingelman-Sundberg), Sabbatsbergs Sjukhus, Stockholm, Sweden

THE CAUSES OF FŒTAL HEAD MOULDING IN LABOUR

BY

LENNART LINDGREN

During labour the fœtal head gets more or less deformed and becomes elongated. In recent papers Borell and Fernström (1958 a and b, 1959) have studied the deformation of the fœtal head during labour by radiological techniques. They demonstrated a particular type of deformation of the fœtal head due to contracted pelvis but also another type of deformation independent of the pelvic size. Further, they found that with hypertonic inertia the parietal bones of the fœtal head are more displaced than with normal labour or hypotonic inertia. During the second stage of labour they found that the moulding tended to diminish.

One of the factors producing deformation of the fœtal head during labour — apart from the configuration of the fœtal head — is that the pressure upon the fœtal head across the axis which becomes lengthened is greater than the pressure in that axis. This has been proved by intra-uterine tocography (Ingelman-Sundberg, Lindgren, and Ljungström, 1952, 1953). If the amniotic water is sufficient, the same pressure prevails in all parts of the uterine cavity (Ingelman-Sundberg and Lindgren, 1954, 1955) and, therefore, it has been assumed, also upon all parts of the fœtal head. On the contrary, it was established that, at the greatest circumference of the head after having been fixed in the uterus, the pressure in normal labour was three to four times greater than the corresponding amniotic pressure and tone (Lindgren, 1955). Below the greatest circumference the pres-

sures declined towards the lower pole of the fœtal head. The conclusion therefore was drawn that as a rule the moulding of the fœtal head during the first stage of labour is caused by the uterus and not by the pelvis (Lindgren, 1957).

With a view to determining the exact influence of different factors on the moulding of the fœtal head during the first stage of labour, the intra-uterine pressures for groups of patients with different types of contraction have been compared. The corresponding pressures in the birth canal during the second stage of labour have also been studied in *primigravidæ* and *multigravidæ* with normal labour.

Method and Case Material

The method for intra-uterine tocography developed by Ingelman-Sundberg and Lindgren (1955) was adopted. Only patients with *occipito-anterior vertex presentations* and without any signs of contracted pelvis were included. The amniotic pressure, the pressure between the fœtal head and the uterine wall during the first stage and the vaginal wall and the pelvic floor during the second stage of labour were recorded at the greatest circumference of the head and 3 cm. below this.

The composition of the series appears from Table I. All the patients with normal contractions (Fig. 1) and hypotonic inertia had well limited contractions with no pain during the intervals. The patients with spasm in the lower uterine segment (Fig. 2) and with uterine fibrillation (Fig. 3) had continuous pain. In the patients with spasm the contractions could be defined by palpation whereas in those with uterine fibrillation they could not be defined with certainty. In the patients with normal contractions and with spasm of the lower uterine segment the contractions were, as a rule, registered from the moment the cervix was "taken up" until it was completely dilated. In those with uterine fibrillation and hypotonic inertia the recording of the contractions was carried out for an hour, on an average, when the cervix was between 3 cm. and 6 cm. dilated. The contractions were recorded throughout the second stage (Fig. 4) in the patients in normal labour after rupture of the membranes. There were no signs suggestive of contracted pelvis.

Table I. *Composition of the Case Material*

	First Stage of Labour					Second Stage of Labour	
	Normal Labour		Spasm of the Lower Uterine Segment	Uterine Fibrillation	Hypotonic Inertia	Primigravidæ	Multigravidæ
	Primigravidæ	Multigravidæ					
No. of patients	4	8	10	8	6	5	5
Mother's age (years)	26.2±1.3	27.9±2.0	26.7±1.5	26.6±2.4	24.0±1.1	25.3±1.9	27.4±2.4
Weight of fœtus (g.)	3295±250	3470±135	3650±177	3700±128	3485±144	3290±210	3400±190
Circumference of fœtal head (cm.) (circumferentia occipito-bregmatica)	32.4±0.6	34.0±0.6	34.3±0.7	33.9±0.3	33.1±0.2	33.2±0.8	34.1±0.5
Contractions recorded	305	213	640	409	109	159	49

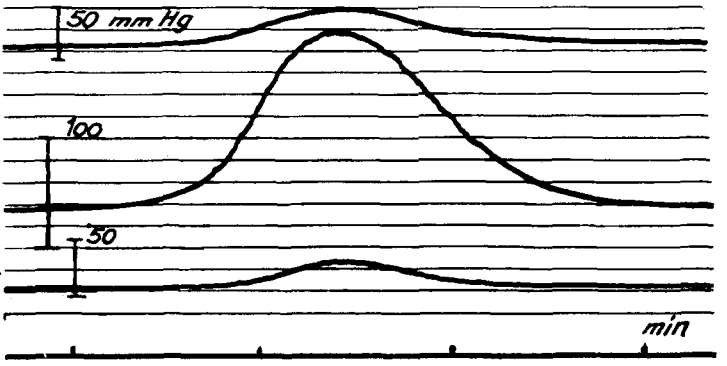

Fig. 1. Normal contraction. *Upper tracing:* Amniotic pressure. *Middle tracing:* Pressure at the largest circumference in the lower uterine segment. *Lower tracing:* Pressure in the cervix 6 cm. below the largest circumference. The pressure in the lower uterine segment is about 4 times higher than the corresponding amniotic pressure.

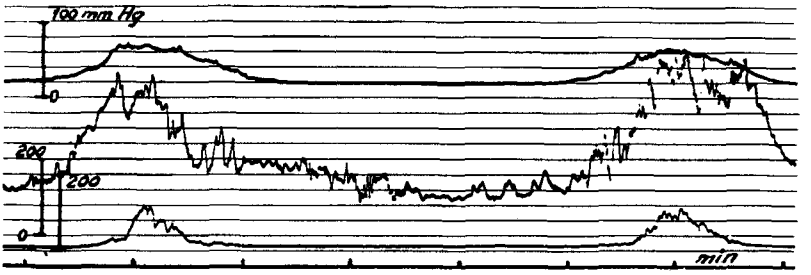

Fig. 2. Spasm in the lower uterine segment. Recording as in Fig. 1. The superimposed pattern in the *middle tracing* corresponds to the spastic contractions of the lower uterine segment.

The Maximum Pressures during Contraction

First stage of labour. The mean amniotic pressure and the mean pressures in the lower parts of the uterus are shown in Table II for the various groups.

The mean pressure at the largest circumference of the head is three to four times higher than the corresponding amniotic pres-

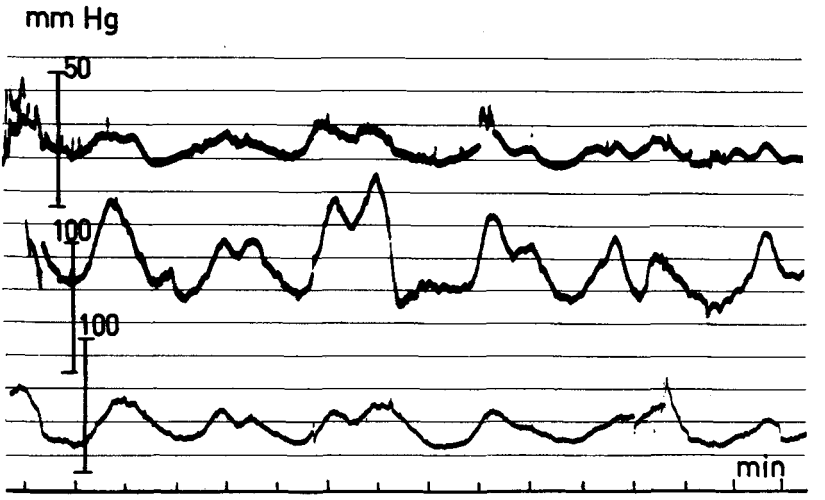

Fig. 3. Uterine fibrillation. *Upper tracing:* Amniotic pressure. *Middle tracing:* Pressure at the largest circumference in the lower segment. *Lower tracing:* Pressure 3 cm. below the registration of the middle tracing in the cervix. The pressure in the lower uterine segment and in the cervix are mainly conditioned by transmitted amniotic pressures.

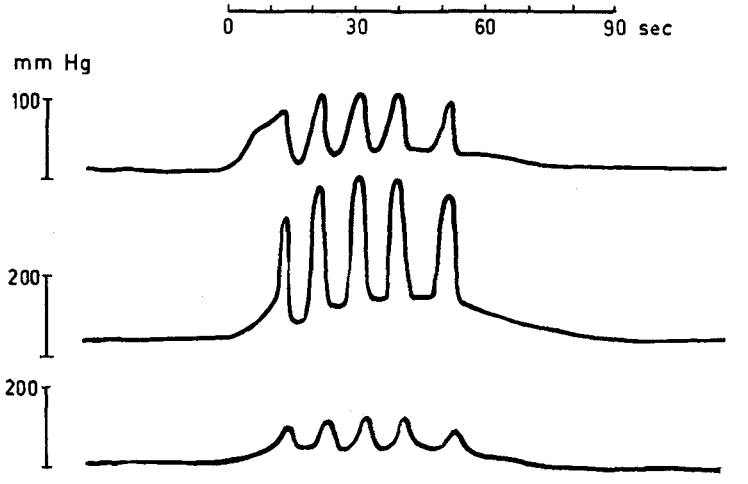

Fig. 4. Bearing-down contraction at the beginning of the second stage of labour. *Upper tracing:* Amniotic pressure. *Middle tracing:* Pressure between the largest circumference of the fœtal head and the cervix. *Lower tracing:* Pressure between the fœtal head and the vagina 3 cm. below the registration of the middle tracing. The spikes correspond to the bearing-down force added to the uterine pressure.

sure in normal labour, uterine fibrillation and hypotonic inertia and somewhat higher at spasm in the lower uterine segment. The patients with spasm show about the same mean pressure at the largest circumference of the head as the *multigravidæ* with normal contractions. After the spastically contracted region of the lower uterine segment has been drawn up above the largest circumference of the fœtal head (at a cervical dilatation of 8 cm. or more) these mean pressures decline. In uterine fibrillation and hypotonic inertia the pressures in the lower uterine segment are low, too, owing to the low amniotic pressures. After spontaneous correction or oxytocin administration, they rise to about the same levels as with normal contractions.

The mean pressures between the fœtal head and the uterine wall successively declined towards the lower pole of the head. In this series the mean pressures 3 cm. below the largest circumference of the head were recorded and were, on an average, only twice the amniotic pressure.

After rupture of the membranes (Fig. 5) the mean amniotic pressure and the maximum pressure at the largest circumference of the fœtal head rose in all groups, whereas it declined 3 cm. below the greatest circumference except with spasm of the lower uterine segment.

Second stage of labour. The mean amniotic pressure and the mean pressure at the largest circumference of the fœtal head (*circumferentia occipito-bregmatica*) and 3 cm. below this are listed in Table III. The Table shows the pressure conditions during the descent of the head and when the head reaches the pelvic floor with and without bearing-down efforts. The pressures obtained have been compared with the corresponding pressures at the end of the first stage of labour when the resistance consists of the cervix.

During the end of the first stage of labour the mean pressure at the largest circumference of the head was higher than the corresponding pressure 3 cm. below both in *primigravidæ* and *multigravidæ*. When the head descended there was no significant difference between the mean pressure in both groups of patients both with and without bearing-down efforts. At the end of the second stage of labour, when the head had reached the pelvic floor the

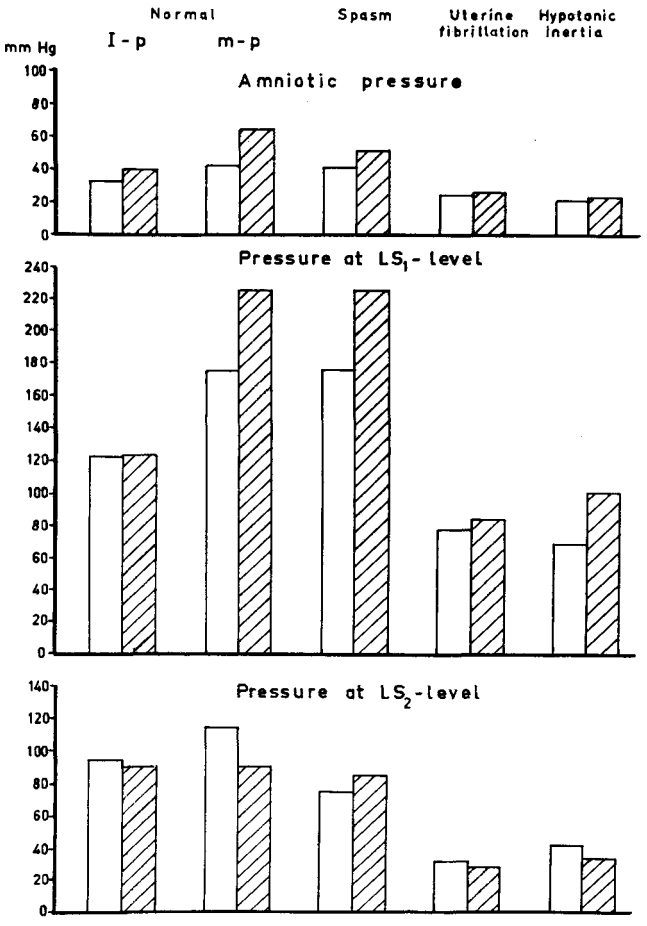

Fig. 5. Mean maximum pressures during contraction. First stage of labour.

before rupture of the membranes.

after rupture of the membranes.

mean pressure was higher 3 cm. below the largest circumference of the head than it was at the largest circumference both in *primigravidæ* and *multigravidæ*.

The Tone

First stage of labour. The mean values of the tone are listed in Table II. For patients with normal labour the amniotic tone was about 9 mm. Hg, for patients with hypertonic inertia about 15 mm. Hg and for patients with hypotonic inertia, on an average, about 6 mm. Hg. After the correction of spasm in the lower uterine segment and uterine fibrillation the tone declined to about 9 mm. Hg and after oxytocin administration for hypotonic inertia the amniotic tone rose to about 12 mm. Hg, *i. e.* to normal values. No definite difference before and after the rupture of the membranes could be demonstrated (Fig. 6).

The average tone at the largest circumference of the fœtal head was barely 30 mm. Hg for patients in normal labour and was approximately the same in *primigravidæ* and *multigravidæ*. With spasm in the lower uterine segment this figure was about 50 mm. Hg, with uterine fibrillation about 40 mm. Hg, and with hypotonic inertia barely 20 mm. Hg. After rupture of the membranes the tone at the largest circumference was higher with spasm and uterine fibrillation than before rupture of the membranes, whereas at normal labour and hypotonic inertia no difference could be shown. After the correction of spasm and uterine fibrillation as well as after oxytocin administration in hypotonic inertia, the tone settled at approximately 30 mm. Hg. The average tone at the largest circumference of the head was about thrice as high as the corresponding amniotic tone.

The average tone 3 cm. below the largest circumference of the head was, for the various groups, about 1.5 times as high as the corresponding amniotic pressure. All the groups showed lower tone at this circumference after the rupture of the membranes.

Second stage of labour. The mean values of the amniotic tone, the tone at the largest circumference of the fœtal head (*circumferentia occipito-bregmatica*) and 3 cm. below this circumference in *primigravidæ* and *multigravidæ* in normal labour are listed in Table III.

There was no significant difference in the amniotic tone and the tone at the largest circumference of the head between the first and the second stage of labour. Three centimetres below this cir-

Table II. *Mean Values of Pressure (mm. Hg). First Stage of Labour*

	Normal		Spasm in the Lower Uterine Segment (Cervix 2–8 cm.)	Uterine Fibrillation	Hypotonic Inertia	After Correction		
	Primigravidæ	Multigravidæ				Spasm (Cx 8–10)	Uterine Fibrillation	Hypotonic Inertia
Amniotic pressure	34.4±0.8	49.3±1.3	47.9±0.9	25.0±0.5	22.6±0.5	60.8±3.6	38.4±1.6	33.6±1.2
Pressure at LS_1	123.6±2.5	187.3±5.5	200.9±3.2	81.0±2.0	78.1±2.4	168.8±4.8	155.0±2.4	142.2±6.2
Pressure at LS_2	93.5±3.0	108.0±5.3	80.7±2.5	29.7±1.1	31.9±2.9	104.2±4.5	56.2±3.6	58.5±5.8
Amniotic tone	8.9±0.3	8.7±0.3	14.9±0.2	15.5±0.2	6.4±0.2	8.7±0.7	9.2±0.4	12.4±1.1
Tone at LS_1	27.4±0.6	29.0±0.6	50.1±1.0	39.9±1.0	18.4±1.5	26.7±2.3	26.4±0.9	33.6±2.4
Tone at LS_2	16.1±0.7	19.1±0.9	19.2±0.5	18.1±0.8	5.8±0.4	18.3±3.6	16.5±1.4	14.0±1.4
Pressure at LS_1 / Amniotic pressure	3.6	3.8	4.2	3.2	3.5	2.8	4.0	4.2
Pressure at LS_2 / Amniotic pressure	2.7	2.2	1.7	1.2	1.4	1.7	1.5	1.7
Tone at LS_1 / Amniotic tone	3.1	3.3	3.4	2.6	2.9	3.1	2.9	2.7
Tone at LS_2 / Amniotic tone	1.8	2.2	1.3	1.2	0.9	2.1	1.8	1.1

LS_1 = pressure at the largest circumference of the fœtal head. LS_2 = pressure 3 cm. below LS_1.

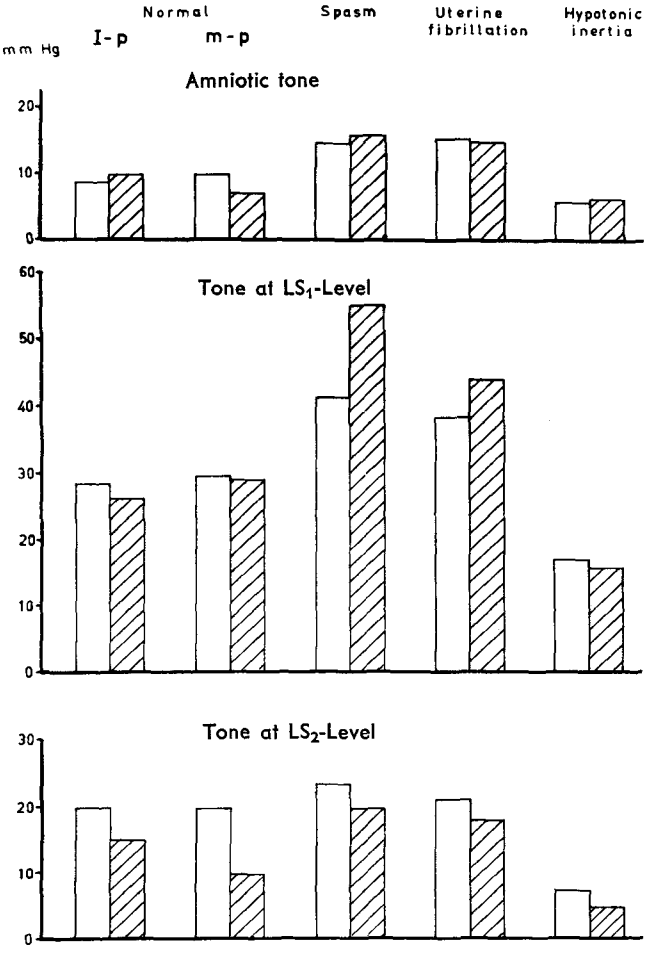

Fig. 6. Mean tone. First stage of labour.

before rupture of the membranes.

after rupture of the membranes.

cumference the tone increased during the second stage both in *primigravidæ* and *multigravidæ*. When the head had reached the pelvic floor the tone 3 cm. below the largest circumference was higher than the tone at that circumference in *primigravidæ* but not different in *multigravidæ*.

Table III. *Mean Values of Pressure (mm. Hg). Second Stage of Labour*

		Primigravidæ			Multigravidæ		
		I	II	III	I	II	III
Without bearing-down force	Am	41.7±2.4	50.0± 1.7	54.4± 1.4	68.9± 4.1	65.0± 2.4	68.6± 2.7
	LS_1	134.3±7.4	108.0±14.7	79.4± 4.4	196.8±13.7	110.7±10.4	89.2± 5.6
	LS_2	64.3±4.6	104.8± 5.8	209.8± 7.4	12.3± 4.5	114.4±11.4	149.9± 8.6
With bearing-down force	Am	–	107.8± 5.2	120.9± 3.4	–	110.9± 5.3	113.8± 3.6
	LS_1	–	145.7±10.9	133.2± 6.3	–	178.4±13.2	140.1±10.7
	LS_2	–	179.3± 9.7	311.3±10.7	–	126.3±12.6	238.7±12.4
Tone	Am	9.3±0.8	9.7± 0.6	10.3± 2.7	10.5± 1.0	10.8± 1.1	10.9± 1.0
	LS_1	29.1±2.4	29.0± 8.5	29.6± 6.4	24.4± 2.5	29.8± 1.9	32.6± 2.9
	LS_2	9.5±2.0	23.4± 2.2	75.6± 4.4	6.7± 2.1	17.1± 0.7	26.5± 3.0

I = at the end of the first stage of labour (Cervix 8—10 cm.).

II = during the first part of the second stage of labour. (The descent of the fœtus.)

III = at the end of the second stage of labour. (From the time the head has reached the pelvic floor until delivery.)

Am = amniotic pressure. LS_1 = the largest circumference of the head (circumferentia occipitio-bregmatica).
LS_2 = 3 cm. below LS_1.

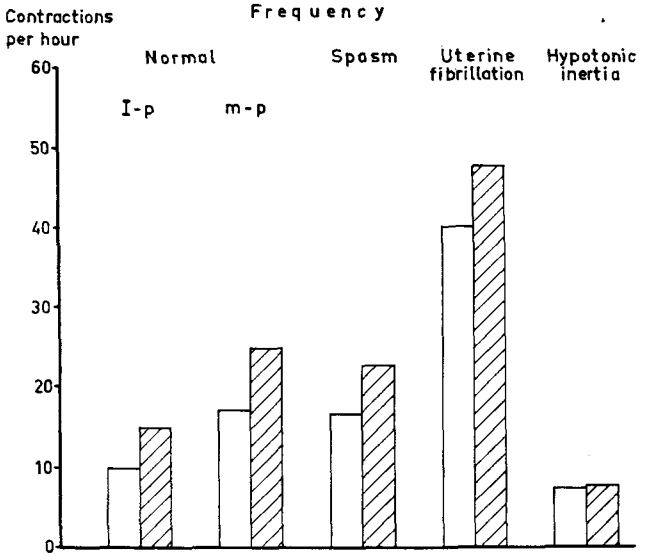

Fig. 7. Mean frequency of the contractions. First stage of labour.

before rupture of the membranes.

after rupture of the membranes.

Frequency of Contractions

The frequency of the contractions in the various groups of patients, registered during the first stage of labour, is shown in Fig. 7. Uterine fibrillation showed 2—3 times as high frequency and hypotonic inertia 2—3 times as low a frequency as the other groups. After the correction it decreased in uterine fibrillation and after oxytocin administration in hypotonic inertia it increased, on an average, to 24 and 18 contractions respectively per hour. In all groups the mean frequency was higher after rupture of the membranes.

The frequency increased during the second stage of labour, but this was not statistically significant. During the end of the first stage the frequency in *primigravidæ* was 23.7 ± 2.4 and in *multigravidæ* 22.9 ± 3.0 contractions per hour. During the descent of the fœtal head it was 25.5 ± 2.6 and 25.7 ± 3.3 respectively and

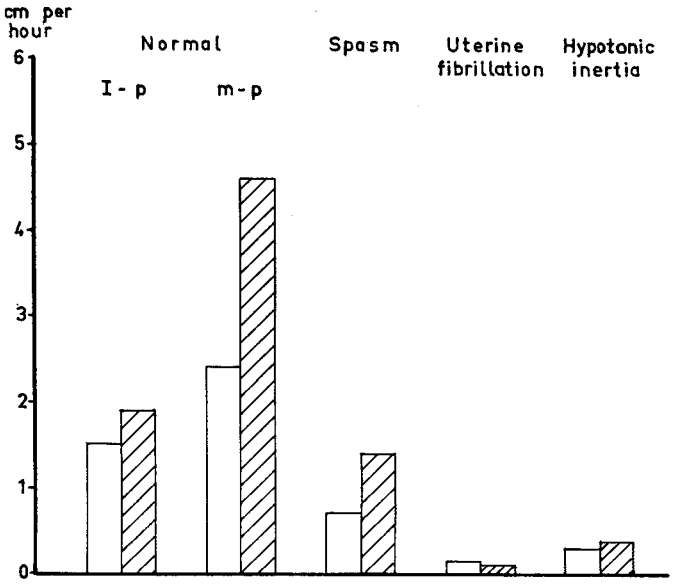

Fig. 8. Rate of cervical dilatation.

before rupture of the membranes.

after rupture of the membranes.

when the head had reached the pelvic floor until delivery 28.1 ± 1.6 and 30.1 ± 4.7.

Rate of Cervical Dilatation

The rate of dilatation of the cervix is recorded in Fig. 8, the rate having been converted to centimetres per hour. *The multigravidæ* with normal contractions showed about twice as high a mean rate of dilatation as the *primigravidæ*. With spasm of the lower uterine segment it was about half the rate of dilatation for primigravidæ with normal contractions, with uterine fibrillation about $^1/_{12}$, and with hypotonic inertia about $^1/_4$. However, with uterine fibrillation and hypotonic inertia only part of the dilatation was recorded and the degree of dilatation was counted from the time the cervix was "taken up". For patients with normal contractions and spasm in the lower uterine segment the rate of

dilatation after rupture of the membranes increased, whereas no definite difference was noticed with uterine fibrillation and hypotonic inertia.

Duration of Second Stage of Labour

The mean time of the descent of the fœtal head was in *primigravidæ* 38.4±18.8 and in *multigravidæ* 8.6±4.1 minutes and it took 32.2±7.0 minutes in *the former* and 10.4±2.9 minutes in *the latter* from the time the fœtal head had reached the pelvic floor until delivery.

Discussion

The investigation confirms our earlier observations that the pressure at the largest circumference of the fœtal head during the first stage of labour both during and between the contractions is higher than the corresponding amniotic pressure and the pressure below this circumference. This applies to all types of contraction recorded here. As the forces at the largest circumference of the fœtal head mainly operate at right angles to the pelvic axis, the fœtal head becomes lengthened because of the lower pressures (amniotic pressure) above and below the maximum circumference. Thus, both the pressures during and between the contractions contribute to the moulding of the fœtal head.

Borell and Fernström (1958a, 1959) have by X-ray studies shown that the moulding of the fœtal head is greater in hypertonic inertia than in normal labour and not so great in hypotonic inertia. In the present study spasm of the lower uterine segment and uterine fibrillation have been investigated, which together are probably representative of hypertonic inertia.

Further, the material investigated shows that the maximum pressure during contraction at the largest circumference of the head is much higher for *multigravidæ* than for *primigravidæ* with normal contractions. This does not seem to be of decisive importance in the moulding of the head during labour as the heads of infant's delivered by *multigravidæ* are not more frequently or more markedly moulded than those of *primigravidæ*. Also, in this

study, *multigravidæ* with normal contractions showed the same high mean pressures as the patients with spasm while the patients with uterine fibrillation had low mean maximum pressures at the largest circumference of the head. This goes to prove that those pressures are not of importance in producing the increased deformation of the head in hypertonic inertia.

The tone at the largest circumference of the fœtal head was much higher both with spasm of the lower uterine segment and uterine fibrillation compared with the corresponding tone in patients with normal contractions. In hypotonic inertia this tone was, on the average, less than in patients with normal contractions. It therefore seems that the tone at the largest circumference of the head is an important factor in the more severe moulding of the fœtal head with hypertonic inertia during the first stage of labour. This also explains why the deformation of the fœtal head is not so great with hypotonic inertia.

The frequency of the contractions alone does not seem to be of great importance. It is true that it is high with uterine fibrillation but it is normal with spasm of the lower uterine segment.

The rate of the cervical dilatation is notably slower with spasm of the lower uterine segment, uterine fibrillation and hypotonic inertia than with normal contractions. This seems to be of importance in producing the greater deformation of hypertonic inertia but of no great importance with hypotonic inertia, as the tone at the largest circumference of the head with this type of contraction is low.

After rupture of the membranes the tone increases at the largest circumference of the head in hypertonic inertia and decreases downwards but, as was shown earlier (Lindgren, 1959 b), the cervical dilatation becomes more rapid, which cuts down this stress. The rupture of the membranes, therefore, does not seem to be of decisive importance in producing the deformation of the fœtal head during the first stage of labour.

After the spastically contracted musculature below the largest circumference of the fœtal head has been drawn up above the largest circumference, *i. e.* at 8—10 cm. of cervical dilatation, and after correction of uterine fibrillation, the tone decreases at that circumference and the rate of cervical dilatation increases.

These two factors in combination seem to decrease the deforming effect on the fœtal head.

In an earlier paper (Lindgren *et al.*, 1958) it was shown that cerebral hæmorrhage (rupture of tentorium cerebelli) was 15 times more common as a cause of infant death with primary inertia than with normal labour. The explanation seems to be the high pressures to which the fœtal head is subjected in hypertonic inertia.

During the second stage of labour the highest pressure acts below the largest circumference on the fœtal head and counteracts the deformation of the head during the first stage of labour, according to the investigations of Borell and Fernström (1958 a, 1959).

SUMMARY

Thirty-six patients in labour (12 with normal contractions, 10 with spasm in the lower uterine segment, 8 with uterine fibrillation, and 6 with hypotonic inertia) have been investigated by intra-uterine tocography to find the causes of the moulding of the fœtal head during the first stage of labour. Recordings were made of 1,757 contractions. The amniotic pressure, the amniotic tone, the pressures at the largest circumference of the fœtal head and 3 cm. below that circumference were measured together with the frequency of the contractions and the rate of cervical dilatation. The corresponding pressure conditions during the second stage in normal labour were also registered in 5 *primigravidæ* and 5 *multigravidæ*, 208 contractions being recorded.

The investigation confirms earlier observations that the pressure at the largest circumference of the fœtal head, both during and between the contractions, is higher than the corresponding amniotic pressure and the amniotic tone as well as the corresponding pressure below the maximum circumference. This proves the conditions for the deformation of the fœtal head during the first stage of labour.

The greater deformation of the fœtal head during the first stage of labour with hypertonic inertia recorded by Borell and Fernström (1958 a, 1959) at X-ray examinations is due to

the higher tone at the largest circumference of the fœtal head while the diminished moulding with hypotonic inertia is accounted for by low tone at this circumference.

The corresponding pressures during the second stage of labour showed that the high pressure on the fœtal head acts below the largest circumference of the fœtal head (*circumferentia occipito-bregmatica*). This pressure counteracts the pressure during the first stage and explains the observation by Borell and Fernström that the deformation of the fœtal head diminishes during the second stage of labour.

REFERENCES

Borell, U. and *Fernström, I.*, Geburtsh. und Frauenheilk. *18*, 1156, 1958 a
— Geburtsh. und Frauenheilk. *18*, 1245, 1958 b
— Acta Obst. et Gynec. Scandinav. *38*, 181, 1959
Ingelman-Sundberg, A. and *Lindgren, L.*, Förh. Nord. Fören. Obstet. Gynek. 8:e möte, p. 168, 1954
— J. Obst. & Gynæc. Brit. Emp. *62*, 629, 1955
— Arch. Gynäk. *192*, 69, 1959
Ingelman-Sundberg, A., Lindgren, L., and *Ljungström, T.*, Förh. Nord. Fören. Obst. Gynek. 7:e möte, p. 163, 1952
— J. Obst. & Gynæc. Brit. Emp. *60*, 321, 1953
Lindgren, L., Acta Obst. et Gynec. Scandinav. *34*, Suppl. 2, 1955
— Nordisk Medicin *57*, 918, 1957
— Arch. Gynäk. *191*, 201, 1958
— Arch. Gynäk. *191*, 467, 1959 a
— Arch. Gynäk. *192*, 308, 1960 a
— Arch. Gynäk. *192*, 314, 1960 b
— Acta Obst. et Gynec. Scandinav. *38*, 211, 1959 b
Lindgren, L., Normann, P., and *Viberg, L.*, Acta Obst. et Gynec. Scandinav. 482, 1958