EFFECT OF ANTENATAL HYPOXIA ON THE NEWBORN RAT CRY

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The method of acoustic spectrography, first used to analyze the newborn infant's cry by Wasz-Höckert et al. in the early 1960s, enables the sound as pronounced to be visualized and some of its parameters to be assessed objectively [7]. Up to 15 characteristics can be distinguished on the spectrogram of the cry of a newborn infant (sonagram) [2], including the duration of vocalization, the maximal and minimal pitch of the principal tone, the type of melody, and so on. By spectrographic investigation, it has been possible to discover a considerable difference between the cry of sick and healthy infants. The greatest changes in cry character have been found in diseases affecting the brain: bacterial meningitis [5], hydrocephalus [8], severe feeding disturbances [2], and birth asphyxia [3]. In the last case, the diagnosis was based on estimation according to the Apgar scale (6 and below), and discoloration of the amniotic fluid with meconium.

The aim of the present investigation was to study the diagnostic possibilities of acoustic spectrography on an experimental model of intrauterine hypoxia. By this experimental approach, it is possible to record accurately the depth and duration of hypoxia and to study its effect in a pure form, without any complicating diseases.

EXPERIMENTAL METHOD

Wistar rats were used. Hypoxia was induced in the fetuses by ligation of the umbilical cord [1]. The operation was performed on the 17th-21st day of intrauterine development. The depth of hypoxia was judged by the fetal pulse rate: the asphyxia was terminated when the pulse rate had fallen to 50 beats/min, after 12-20 min. In a separate series of experiments, the partial pressure of oxygen in the brain tissue under these circumstances was shown to have fallen to 30-40% of its initial level. In control fetuses, the pulse rate remained at its initial value (200-280 beats/min) throughout the period of investigation. On the 1st, 2nd, and 3rd days of life of the rats their cry, both spontaneous and evoked by nociceptive stimulation (pricking the hind limb), was recorded on a "Kometa" or "Vesna" tape recorder and then analyzed on a type 7029 A "Sona-Graph" (Kay Elemetrics, USA) with respect to three parameters: the maximal and minimal pitch of the principal tone and the duration of the acoustic signal. Three groups of animals were used: 1) control rats born from intact mothers (n = 20), 2) control rats whose mothers had undergone the operation (n = 21), 3) rats exposed to intrauterine hypoxia (n = 28).

EXPERIMENTAL RESULTS

Values of the minimal and maximal pitch of the principal tone in spontaneous and evoked cries are given in Table 1. In animals exposed to hypoxia in the intrauterine period (group 3) both these parameters were higher than in the control rats, especially on the first day of life. On the 2nd and 3rd days, the difference became less pronounced, and in the case of the spontaneous cry, the minimal and maximal pitch sometimes was actually a little (not statistically significant) lower than in the control animals. This was due to the great individual variations in pitch of the principal tone in the animals, both healthy and asphyxiated. In animals surviving the first day, some degree of normalization of the general state evidently took place. Rats with severe posthypoxic lesions died on the first day after birth and had the highest funda-

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TABLE 1. Minimal and Maximal Pitch of Fundamental Tone in Spontaneous and Evoked Cry (M ± m)

Age of rats, days	Minimal pitch, Hz			P_{I-II}	P_{I-III}	P_{II-III}	Maximal pitch, Hz			P_{I-II}	P_{I-III}	P_{II-III}
	group 1	group 2	group 3				group 1	group 2	group 3			
						Evoked cry						
1	1854±65 (n=77)	1647±123 (n=19)	2211±233 (n=26)	—		<0,05	2964±72 (n=78)	3505±230 (n=19)	4265±146 (n=26)	<0,05	<0,001	<0,01
2	2082±144 (n=35)	2317±302 (n=12)	2422±299 (n=14)	—	—	—	3070±52 (n=37)	3864±303 (n=11)	3964±230 (n=14)	<0,01	<0,001	—
3	2390±110 (n=31)	2464±253 (n=14)	2490±255 (n=21)	—	—	—	3220±100 (n=35)	3936±274 (n=14)	4081±238 (n=21)	<0,02	<0,001	—
						Spontaneous cry						
1	2052±142 (n=17)	1738±274 (n=13)	2210±273 (n=19)	—	—	—	2931±146 (n=18)	3546±245 (n=13)	3652±227 (n=19)	<0,05	<0,01	—
2	1900±352 (n=7)	1992±281 (n=12)	1707±226 (n=15)	—	—	—	2775±160 (n=8)	3475±288 (n=12)	3073±261 (n=15)	<0,05	—	—
3	2100±326 (n=5)	2175±339 (n=8)	1769±254 (n=13)	—	—	—	2937±132 (n=8)	3788±431 (n=8)	3831±306 (n=13)	—	<0,02	—

Legend. Number of observations in parentheses.

TABLE 2. Cumulative Frequency of Appearance (in %) of a Given Pitch of Fundamental Tone during Evoked and Spontaneous Cry in Rats

Age of rats, days	Group	Minimal pitch, Hz				Maximal pitch, Hz				
		>4000	>3500	>3000	>2500	>5500	>5000	>4500	>4000	>3500
					Evoked cry					
1	1	—	—	2,6	14,3	—	—	—	—	8,8
	2	—	—	5,3	5,3	—	5,3	21,2	36,9	52,7
	3	7,6	15,3	19,1	30,6	3,8	15,3	30,7	61,5	84,6
2	1	—	—	5,7	31,4	—	—	—	—	10,8
	2	—	25	33,3	41,6	9,1	9,1	9,1	45,5	72,8
	3	21,4	21,4	35,7	35,7	—	—	7,7	50,5	64,8
3	1	—	—	9,7	31,7	—	—	—	—	25,7
	2	—	21,4	35,8	42,9	—	14,3	28,7	49,8	71,2
	3	9,5	33,3	42,8	42,8	9,5	14,3	38,1	47,6	76,2
					Spontaneous cry					
1	1	—	—	—	23,5	—	—	—	—	16,7
	2	—	7,6	15,2	15,2	—	—	15,4	30,8	61,5
	3	5,3	21,1	36,6	36,6	5,3	5,3	15,8	47,4	47,4
2	1	—	—	—	28,6	—	—	—	—	—
	2	—	8,3	24,9	24,9	—	—	—	25	66,7
	3	—	6,7	13,4	13,4	—	—	—	13,4	46,7
3	1	—	—	—	20	—	—	—	—	—
	2	—	12,5	25	25	—	12,5	37,5	50	50
	3	—	3,3	3,3	14,4	—	7,7	15,4	53,9	77

TABLE 3. Duration of Acoustic Signal (in sec)

Age of rats, days	Group 1		Group 2		Group 3		P_{I-II}	P_{I-III}	P_{II-III}
	n	$M \pm m$	n	$M \pm m$	n	$M \pm m$			
					Evoked cry				
1	78	0,28±0,01	16	0,21±0,02	23	0,17±0,02	<0,001	<0,001	—
2	39	0,23±0,01	13	0,20±0,04	16	0,11±0,02	—	<0,001	<0,05
3	37	0,21±0,01	11	0,11±0,01	15	0,13±0,02	<0,001	<0,001	—
					Spontaneous cry				
1	19	0,22±0,02	14	0,18±0,02	20	0,18±0,02	—	—	—
2	10	0,16±0,02	13	0,18±0,02	16	0,19±0,02	—	—	—
3	10	0,16±0,02	10	0,17±0,02	15	0,18±0,02	—	—	—

mental pitch when their cry was recorded: in rat No. 3, born from rat No. 12 1 h before death, for instance, the minimal pitch of the fundamental tone was 5400 Hz in the evoked and 5300 Hz in the spontaneous cry, i.e., almost 3 times higher than the mean pitch for this group; the maximal pitch was 5800 Hz.

The differences in the character of the acoustic signals of the control and asphyxiated animals became more evident when the frequency with which each pitch of the fundamental tone was found. As Table 2 shows, in the control intact animals (group 1), during the first 3 days of life there were practically no values of minimal pitch of the fundamental tone above 3000 Hz or of a maximal pitch above 4000 Hz. Meanwhile, in rats of group 3, exposed to hypoxia, the minimal pitch was over 4000 Hz and the maximal over 5500 Hz, i.e., the distribution curve was shifted to the right compared with that of the intact animals. Control rats born from animals undergoing the operation occupied an intermediate position.

The increase in frequency of the fundamental tone in the animals exposed to hypoxia in harmony with results obtained by investigation of infants with asphyxia [3]. This phenomenon may be attributed to injury to various brain structures, especially nuclei of the thalamus and hypothalamus, observed on histological investigation of the experimental animals' brain [1]. As has been shown [9], stimulation of these brain regions evokes changes in cry in rats similar to those observed in the present investigation.

The duration of the acoustic signal in animals exposed to antenatal hypoxia was less than in the control animals (Table 3). The investigation of external respiration shows that the respiratory volume of the experimental animals was 40% less than in the controls. Zhukova and Hallman have shown with this model of antenatal hypoxia that development of the lungs and synthesis of surfactants in them are considerably disturbed. It can be tentatively suggested that disturbances of respiration are responsible for some of the changes in character of the cry and, in particular, for its shorter duration, in animals exposed to hypoxia.

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