DEVELOPMENT OF A COMPUTER ASSISTED MOTILITY MONITORING SYSTEM FOR EVALUATION OF SLEEP PATTERNS OF NEWBORNS

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ABSTRACT

Objective: Many scientists have hinted that the newborn period may offer uniquely favourable conditions for assessing the functional status and adaptive capacities of infants. Thus in this study, a system has been developed for monitoring the motility and for evaluating the sleep patterns of normal and asphyxiated newborns.

Methods: The system consists of a commercially available pressure sensitive pad placed under the baby, an amplifier, an A/D converter and an IBM compatible personal computer.

Results: An attempt has been made to detect the sleep states of infants, normal and those with asphyxia using the computerized motility monitoring system. The first 72 hours of life has been evaluated and the sleep patterns of infants have been classified using the same method as Thoman et al.

Conclusion: Although the previous studies indicated that sleep patterns may differ in hypoxic conditions, sleep states of both groups in this study did not have statistically significant difference.

Key words: Sleep pattern, newborn, computer scoring

INTRODUCTION

Infants' sleep patterns have been intensively studied as an indicator of central nervous system (CNS) integrative controls and as a behavioral interface with the environment. Newborns' sleep states have been studied using direct behavioral observations, film and video recordings, parental reports, electrophysiological recordings, and motility recordings. In general, the observations lasted 30 minutes to 3 hours. Sleep states are classified as active sleep, quiet sleep, active quiet transition, sleep wake transition and wake(1).

There is not yet a consensus on whether the newborn's behavioral characteristics during the earliest postnatal period express a passing phase of recovery from perinatal events or whether they might provide indices of the newborns's functional status and later development.

In this study, the sleep patterns of normal and asphyxiated newborns were studied and the results were compared.

MATERIAL AND METHOD

Thirteen normal newborns and 11 newborns with perinatal asphyxia were followed up at Haydapaşa Numune Hospital Pediatrics Clinic between Aptil 1st, 1995 and June 1st, 1995. After the newborns were admitted to the clinic, complete physical and neurological examinations were performed. The Apgar scores at 1 and 5 minutes were recorded.

The newborns with the symptoms of neonatal asphyxia i.e. newborns with low Apgar scores, hypothermia, nasal flaring, intercostal retractions, tachpnea, apnea, bradycardia, convulsions, cyanosis, acidosis and decreased reflexes were considered as newborns having neonatal asphyxia.

Infants having gestational ages less than 38 weeks were considered as premature. Gestational age assessment was done with Dubowitz Method.

Prenatal histories of mothers were obtained. Mothers of infants with neonatal asphyxia were investigated with respect to etiology. Asphyxiated infants were not given any drug that may affect the sleep patterns.

In this study, a special motility monitoring system which is connected to a Personal Computer (PC) to function as recording system for the sleep states of infants 72 hours after birth was used. Sleep and wake states obtained from a pressure sensitive sensor mattress on which the newborn was laid down, were transferred to the computer through an Analogue-Digital (A/D) Converter. The analogue signals produced from the respiration and body movements of the newborns were continuously recorded directly to the hard disc of the computer for three hours. In this way the sleep patterns of the newborns were obtained.

In the study, the output signals from the pressure sensitive mattress sensor (SISS Babycontrol SCHULTE ELECTRONIC GMBH, D 59939, Olsberg, Germany) were converted by a digital converter board (Labboard, PCL 718) and recorded into the hard disc of the PC by using a specific software (Labtech Notebook Data Acquisition Software). The digitilized data were stored in the hard disc of the PC. The data acquisition was performed at a sampling frequency of 10 Hz. The measurements have been taken from 13 healthy subjects and 11 neonatal asphyxia patients.

To process the signals, the data in the hard disc of the PC were changed from binary format to ASCII. Later these data were used for visually classifying and scoring of sleep states. The software was written using Turbo Pascal 7.0.

For sleep scoring the data were manually scored for sleep state and waking activity based on well established scoring criteria for infants (2). Two 30 second epochs per minute were scored. If the duration of a state was two thirds of an epoch a change of state was tabulated. If the duration was less than two thirds of an epoch, it was scored as part of the ongoing state. The recordings were divided into 30 second epochs and visually scored as Active-Sleep, Quiet Sleep, Active-Quiet Transition, Sleep-Wake Transition and Wake.

RESULTS

Of the thirteen normal newborns 7(53.8%) were full term and 6(46.2%) were premature. The premature newborns were between 30 and 37(mean 34.7) weeks of gestational age. Of the 11 asphyxiated newborns 9(81.8%) were full term and 2(18.2%) were premature. The 2 premature newborns were 29 and 37 (mean 33) weeks of gestational ages.

Eight(61.5%) of the normal newborns were females and 5(38.5%) males. From the 6 normal premature newborns 4(66.7%) were females and 2(33.3%) males. From the 11 newborns born with asphyxia 2(18.2%) were females and 9(81.8%) males. Two(100%) premature asphyxiated newborns were males. Mothers of the normal newborns were aged between 16 and 30(mean 25.1) years. Three(23.1%) of the normal infants were born with caesarean section. Normal newborns' birth weights were between 1750 and 4500(mean 3080.8) grams. Normal newborns' APGAR scores at 1 minute were between 6-8(mean 7.2), and at 5 minutes between 8-10(mean 9.1). The recordings of normal infants were performed from 1st to 69th hours (mean 29.3 hours) after birth. Normal infants did not have any complications during and after birth (Table I). Mothers of infants with asphyxia were aged between 19 and 35 (mean 26.2) years. Three(25%) of the asphyxiated infants were born with caesarean section. The gestational ages of asphyxiated newborns were between 29-40(mean 38.17) weeks. Asphyxiated newborns' APGAR scores at 1 minute were between 2-6(mean 4.8), and at 5 minutes were between 5-10 (mean 7.8). The recordings of infants with asphyxia were performed at the 1st through 72nd hours after birth. Six(50%) of the newborns with asphyxia had meconium aspiration. Three(25%) of the newborns with asphyxia were born with caesarean section. One(8.3%) of the patients had convulsions because of hypocalcemia and anticonvulsant drug was used (Table II).

Table III presents sleep patterns of the normal newborns. Sleep patterns of newborns with asphyxia are seen in Table IV.

Table V presents the mean value for each state variable for both groups. There is no significant difference between the two groups as indicated by the t-test results.

Figure 1 demonstrates mean values of sleep states for both groups. Patterns of respiration and body movements which are typical for the states of sleep are given in figures 2-5.

The neurological examination of the babies were normal at 6 months of age.

Table I. Descriptive Profile of Normal Newborns.

Case No.	Age of mother	Delivery	Gestational age(week)	Sex	Weight (grams)	Apgar I	Apgar V	Starting Hour
1	29	V	37	M	3100	7	9	68
2	30	V	38	M	4000	8	9	69
3	33	V	41	F	3200	8	10	4
4	22	CS	38	M	2700	7	9	16
5	27	V	35	F	2200	7	8	59
6	25	CS	38	F	3320	8	10	1
7	16	V	30	F	1750	8	10	3
8	22	V	38	F	2900	7	9	6
9	23	CS	38	F	4400	7	9	54
10	20	V	32	F	2200	8	8	54
11	32	V	37	F	2780	7	9	7
12	26	V	40	M	4500	7	9	35
13	21	V	37	M	3000	7	9	4

V: Vaginal delivery, CS: Caesarean section, M:Male, F:Female.

Table II. Descriptive Profile of Asphxiated Newborns.

Case No.	Age of mother	Delivery	Gestational age(week)	Sex	Weight (grams)	Apgar I	Apgar V	Starting Hour
1	22	V	42	M	3700	6	9	8
2	35	V	39	M	3650	5	8	12
3	28	V	38	F	2900	6	9	2
4	27	CS	38	M	3000	2	5	48
5	28	V	37	M	2800	6	10	2
6	19	CS	39	M	3900	6	9	8
7	19	V	39	M	3150	5	7	72
8	19	V	40	M	3550	5	8	1
9	29	V	39	M	3000	5	10	3
10	30	CS	40	F	3900	3	5	4
11	29	V	29	M	1550	6	8	3

V:Vaginal delivery, CS: Caesarean section, M:Male, F:Female.

Table III. Sleep States of Normal Infants (%).

Case	Active Sleep	Quiet Sleep	Active Quiet Transition	Sleep Wake Transition	Wake
1	16.1	50.0	19.4	1.4	12.8
2	35.6	30.3	10.8	5.6	17.7
3	4.7	57.8	8.6	2.8	26.1
4	29.7	62.5	7.2	0.6	0.0
5	13.6	60.0	8.3	10.0	8.1
6	75.8	9.2	15.0	0.0	0.0
7	40.0	39.2	7.5	6.9	6.4
8	10.0	83.9	5.0	1.1	0.0
9	17.8	60.3	9.6	7.5	5.0
10	50.3	37.0	7.2	3.3	2.2
11	7.8	73.6	4.7	3.1	10.8
12	4.5	73.6	11.7	0.8	9.4
13	1.4	39.4	4.2	6.1	49.9

Table IV. Sleep States of Asphyxiated Infants(%).

Case	Active Sleep	Quiet Sleep	Active Quiet Transition	Sleep Wake Transition	Wake
1	49.4	31.4	3.6	2.8	12.8
2	12.2	86.7	3.6	0.0	0.0
3	8.6	77.2	2.8	1.7	9.7
4	9.2	93.3	5.8	1.1	0.6
5	40.6	49.4	9.2	0.8	0.0
6	8.9	52.8	8.3	8.6	21.4
7	29.7	23.9	46.1	0.3	0.0
8	81.4	14.7	3.9	0.0	0.0
9	44.2	49.1	4.2	0.6	1.9
10	12.8	82.2	4.7	0.3	0.0
11	32.2	65.8	1.7	0.3	0.0

Table V. Mean Values of Sleep States in Normal and Asphyxiated Newborns(%).

Sleep States	Normal	Asphyxia
Active Sleep	28.95	23.63
Quiet Sleep	52.60	57.33
Active Quiet Transition	9.17	7.71
Sleep Wake Transition	3.78	1.70
Wake	11.34	5.14

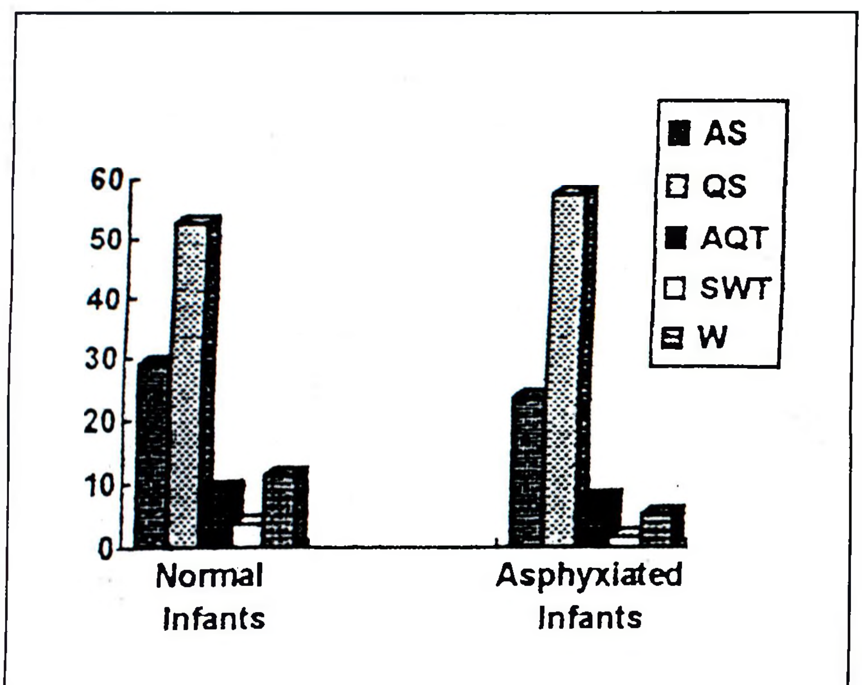

Fig. 1: Mean values of sleep states in normal and asphyxiated newborns.

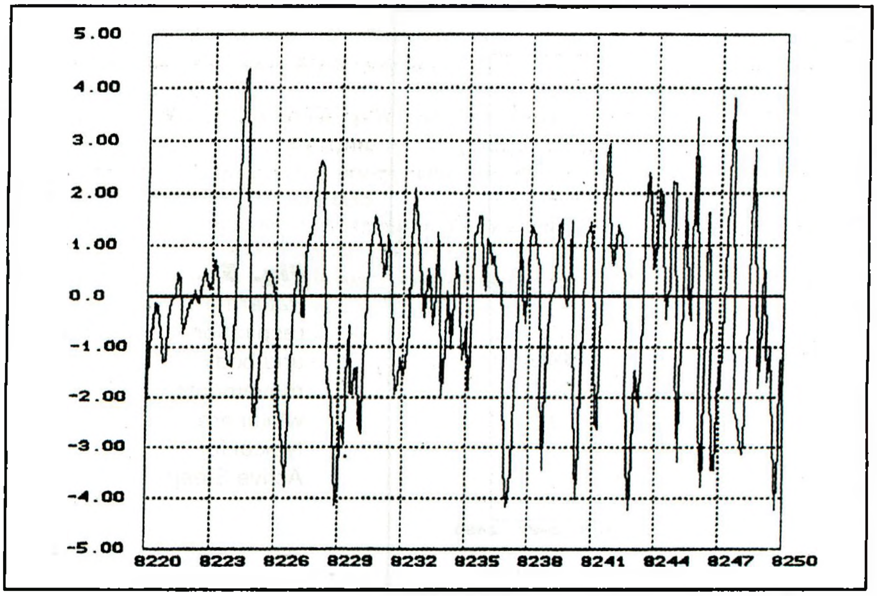

Fig. 2: Pattern of respiration and body movements which are typical for Wakefulness.

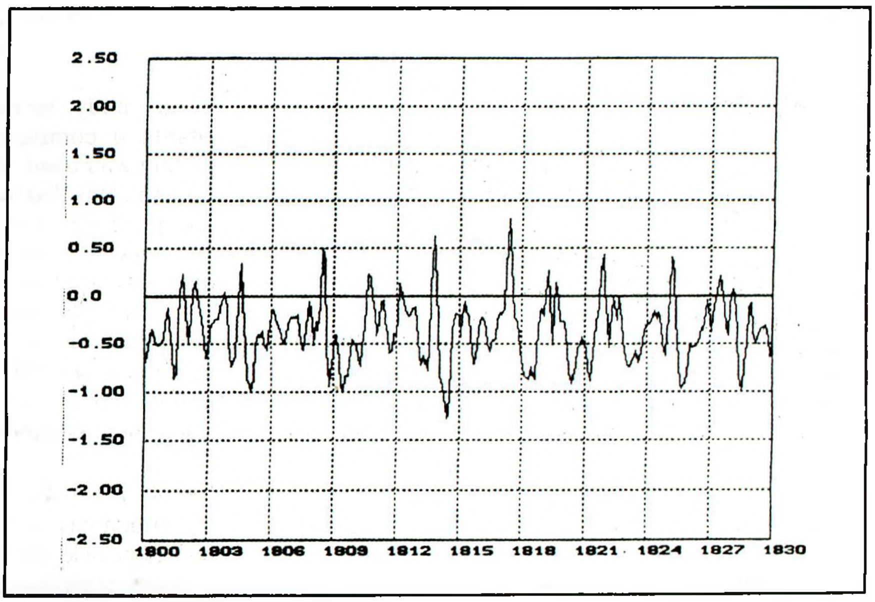

Fig. 3: Pattern of respiration and body movements which are typical for Active-Quiet Transitional Sleep.

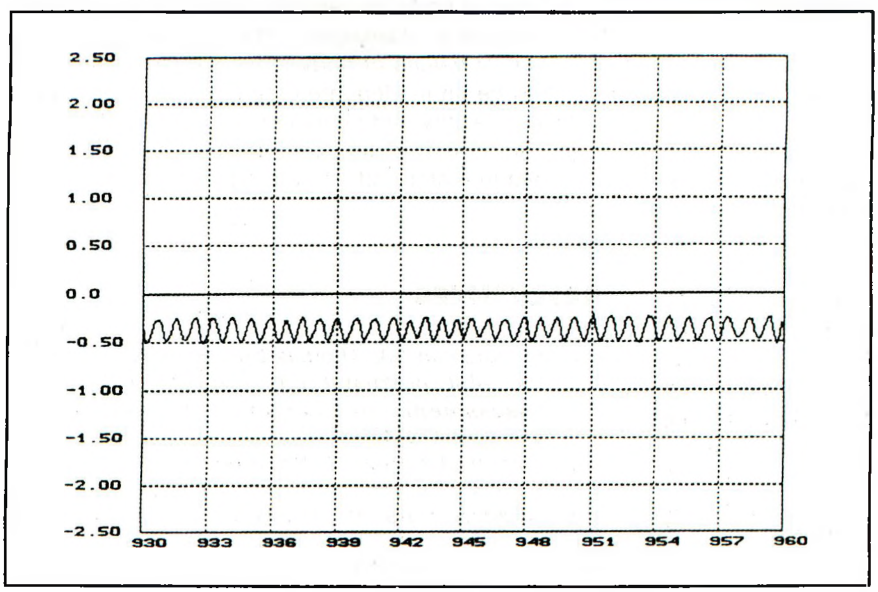

Fig. 4: Pattern of respiration and body movements which are typical for Quiet Sleep.

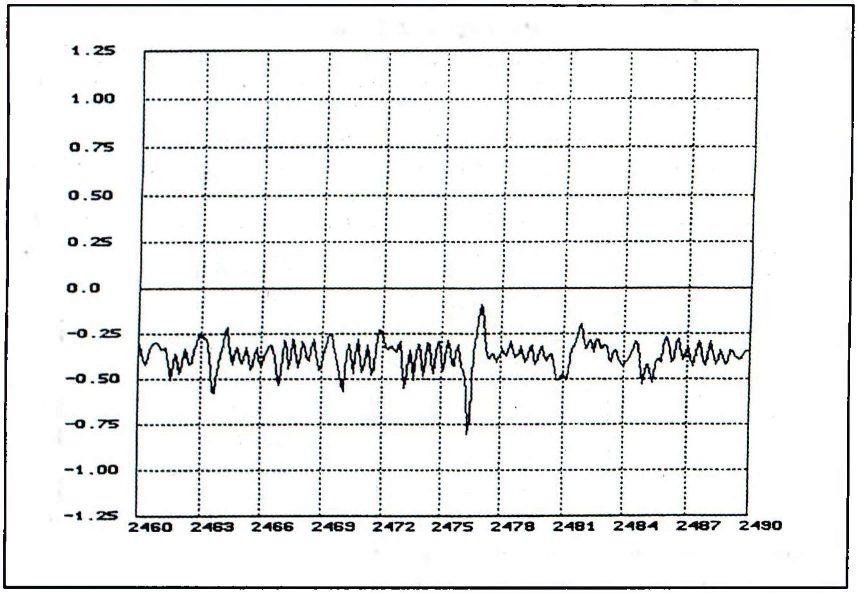

Fig. 5: Pattern of respiration and body movements which are typical for Active Sleep.

DISCUSSION

In the recent years, modern neonatal care has become very effective. Increasing number of premature and sick infants can be brought back to life, and the prognosis of the high risk neonate is often good. This development has increased the importance of assessment of neurodevelopmental outcome in high risk neonates. Attention must be given to neurological and behavioral aspects because the nervous system is at high risk during different impairments in fetuses, preterm and sick infants(3).

A clinical examination of a newborn does not always answer the question whether the newborn later, will be handicapped or not (4,5). The relationship between morbidity and computed tomography (CT) or ultrasonography (US) findings is still controversial (6,7). Up to 40% of infants with intraventricular hemorrhage can later be free of sequels (8). Thus in addition to anatomical and clinical studies, studies of different physiological variables, like body movements of neonates are needed. These studies may provide information on the neurodevelopmental conditions of high risk neonates and also on prognoses. Other than the body movements, infants' sleep patterns can be an indicator of CNS development. Freudigman and Thomas(1) performed a similar study like ours on 36 healthy and term infants during the first postnatal day and arrived to the conclusion that newborns' sleep patterns in the first postnatal day were related to the future neurological development. It is now generally agreed that infants who are at high risk for sudden infant death syndrome have CNS impairment as indicated by studies of sleep patterns(8).

In our study, to detect sleep states of 13 normal infants a computer assissted motility monitoring system was used. We evaluated the first 72 hours of life and classified the sleep patterns of normal infants using the same method as Thoman et al (9) The same procedure was applied to 12 infants with perinatal asphyxia whose sleep patterns may be important for showing neurological development. Although the previous studies indicated that sleep patterns may differ in hypoxic conditions, sleep states of both groups in this study did not have statistically significant difference.

Recently, Prechti and Nolte (2) found no differences in the quantity of body movements between low risk and high risk infants. Also Erkinjuntti, (8) could not find any statistically significant differences in the occurrences of body movements between healthy and neurologically damaged infants. As a result, quantitative values of body movements during sleep seem to be an inadequate criterion for differentiation between healthy and neurologically damaged infants. This emphasizes the importance of qualitative changes in motor patterns during CNS impairment in infants.

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