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ANALYSIS OF FRONTAL SHARP TRANSIENTS IN 32 NEONATAL POLYSOMNOGRAPHY IN HEALTHY FULLTERM NEWBORNS

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ABSTRACT - *Objective:* To identify and quantify frontal sharp transients found in neonatal polysomnography of healthy full term newborns in each stage of the sleep-wake cycle within the first 48 hours of life. *Method:* The EEG from healthy term 32 newborns, legal age of two days and with adequate monitoring during pregnancy. Frontal sharp transients (FST) were quantified, according to synchronous or asynchronous, in each stage of the sleep-wake cycle. The results were compared by Kruskal-Wallis-test. *Results:* FST were counted individually in each sleep phase, being present during quiet sleep (QS) in all tracings. FST bilateral and synchronous and lateralized FST were more frequent during QS ($p<0.05$). *Conclusion:* Lateralized FST were found mostly during quiet sleep. FST asynchronous in healthy full term newborns were normal and depended of FST density. FST unilateral appearance should not necessarily be considered abnormal as well.

KEY WORDS: polysomnography, polygraphyc, EEG, electroencephalogram, sleep, neonatal, frontal sharp transients, encoches frontales.

Análise de transientes agudos frontais em 32 poligrafias neonatais de recém-nascidos saudáveis a termo

RESUMO - *Objetivo:* Identificar e quantificar transientes agudos frontais encontrados em EEG neonatal de recém-nascidos a termo saudáveis em cada estágio do ciclo de sono-vigília nas primeiras 48 horas de vida. *Método:* Foram estudados os EEG de 32 recém-nascidos saudáveis, com até 2 dias de vida e adequada monitorização durante a gestação. Transientes agudos frontais (TAF) foram quantificados como síncronos ou assíncronos, em cada estágio do ciclo de sono-vigília. Os resultados foram comparados pelo teste de Kruskal-Wallis. *Resultados:* TAF foram contados em cada fase do sono, estando presente no sono quieto de todos os traçados. TAF bilateral e síncrono ou lateralizado predominou durante o sono quieto ($p<0,05$). *Conclusão:* TAF lateralizados foram encontrados predominantemente durante o sono quieto. TAF assíncrono em recém-nascidos saudáveis a termo foi normal dependendo da densidade de incidência. TAF unilateral pode não ser considerado anormal.

PALAVRAS-CHAVE: polissonografia, poligrafia, EEG, eletrencefalograma, sono, neonatal, transientes agudos frontais, *encoches frontales.*

The electroencephalogram (EEG) can be used as a diagnostic tool for the investigation of neonatal seizures, and may help in establishing prognosis in certain neonatal conditions[1,2]. Frontal sharp transients (FST) (Figure), first described by Monod[3], are sharp waves occurring in the frontal region, often bilateral and synchronous but at times asynchronous. Asynchrony of FST is not uncommon in normal subjects. Typical biphasic FST appear first at 35-36 weeks gestational age, their frequency occurrence decline between 3 and 5 weeks post-term and they are reportedly absent at 8 weeks after a term birth[4]. FST occur primarily during sleep, particularly during transition from active to quiet sleep[3,5]. FST have biphasic

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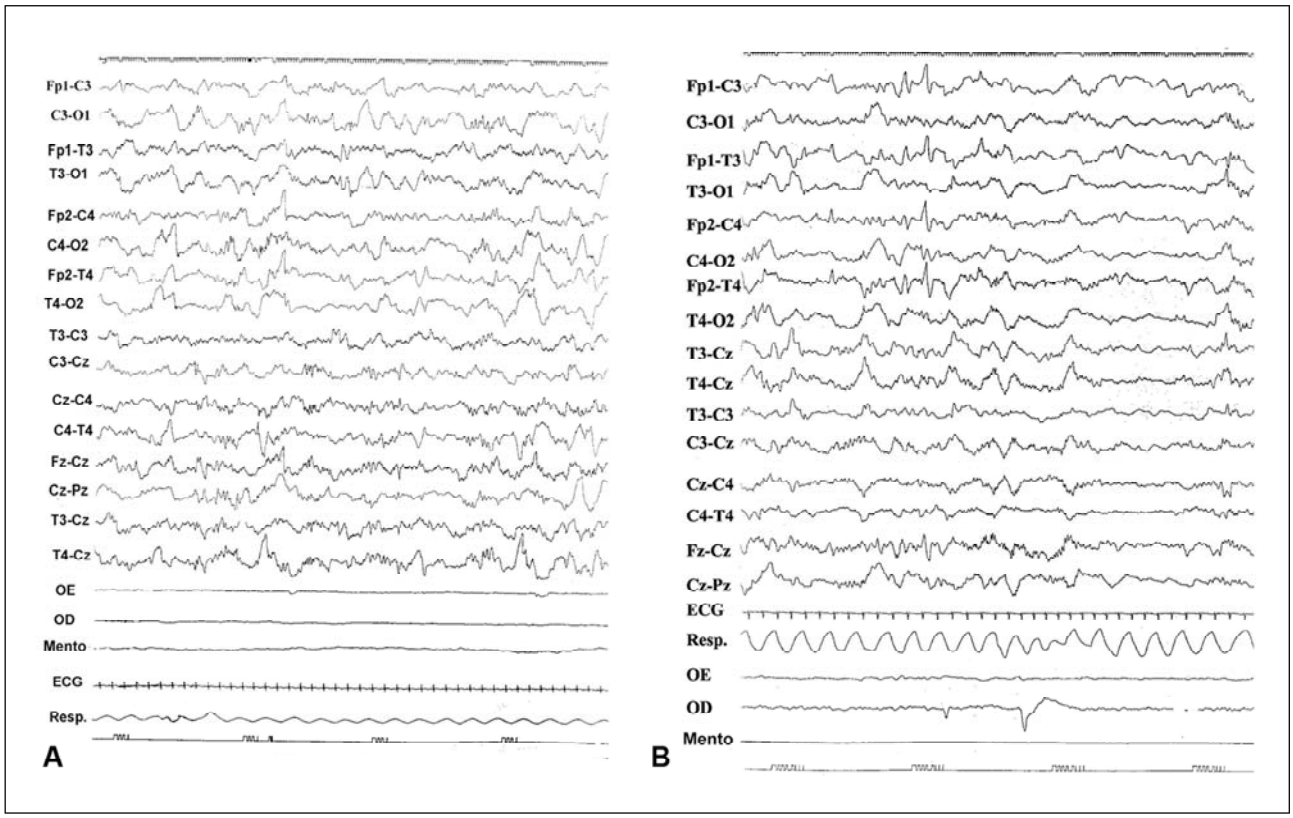

Figure. Morphology of FST (A) unilateral FST, (B) bilateral and synchronous FST.

morphology with a lower voltage negative sharp, wave followed by a higher amplitude positive sharp component. Their maximum amplitude lies over the prefrontal region with a voltage is 50-150 microvolt. They can appear isolated or in bursts, frequently in association with anterior slow dysrhythmia (ASD). Differentiation between them is sometimes difficult. The pattern of ASD consists of bursts of frontally predominant polymorphic or monomorphic 2 to 4 Hz and 50 to 150 microvolts delta activity. FST were more often recorded in a bilateral and synchronous (BS) pattern though many authors have recognized that they can also be assynchronous[6-9].

The EEG can be used as a diagnostic tool for the investigation of neonatal seizures, and may help in establishing prognosis in certain neonatal conditions. Many studies have addressed the graphic elements of EEG recordings in newborns (NB), and their behavior during sleep, to establish the boundaries between normal and pathological findings[6,10-17].

The purpose of this study is to evaluate the characteristics of FST, ASD and FST/ASD in healthy term newborns babies throughout different sleep stages.

METHOD

We studied 32 full term newborn of gestational age (GA) ranging from 38 to 42 weeks, as established by either the Parkin[18] or Dubowitz[19] methods, with a fifth minute Apgar index of 7 or higher and of normal weight for their GA. All EEGs were evaluated within 48 hours after birth. Prenatal evaluation was mandatory to ensure that no mother had received drugs or medication that might potentially damage the fetal central nervous system during pregnancy. NB weight ranged from 2,590 to 3,855 grams (mean 3,206.56 grams). The subjects consisted of 14 females and 18 males at GA, ranging from 38.5 to 41.5 weeks (mean 39.7±0.9 weeks). Fifth minute Apgar indexes ranged from 8 to 10 (mean 9.5) (Table 1). The infants were submitted to a neurological examination, classified by the Denver II scale[20], and were submitted to a second EEG recording between 1 and 2 years of age.

Newborns who were either small or large for GA, or who exhibited neurological abnormalities, such as neonatal hypoxia; respiratory distress; infection; elevated bilirubins; discordance between the EEG and clinical or ultrasonographic GA or date of the last menses, as well as NB who had received medication to induce sleep prior to the recording or second EEG recording abnormal were excluded from the analysis.

The responsible relatives of the newborns gave written informed consent after being fully informed of the research procedure, following approval by the local ethical committee (CEP/HC 570.1519/2002-11).

Polysomnograms (PS) – The NB were placed on a bed

Table 1. Clinical data and duration of polysomnogram recordings.

Case	GA (weeks)	Sex	Weight (grams)	APGAR Scale		Duration of PSG (minutes)
				1st minutes	5th minutes	
1	38.5	f	3,245	8	9	54.00
2	39.5	m	3,315	9	9	75.33
3	38.5	m	3,075	8	9	58.00
4	39.5	f	3,030	9	10	54.33
5	38.5	f	3,855	7	8	47.67
6	38.5	m	2,950	9	10	51.00
7	41	f	2,890	8	10	66.67
8	40	m	2,665	9	10	51.67
9	39.5	f	2,950	8	10	70.00
10	41	f	3,560	9	10	49.33
11	39.5	f	3,075	8	9	63.00
12	38.5	m	3,155	8	10	57.33
13	38.5	m	3,085	7	9	57.33
14	41.5	m	3,155	10	10	63.33
15	39.5	m	2,900	9	9	35.33
16	38.5	m	3,065	8	9	54.00
17	41	m	3,350	3	9	67.67
18	39.5	m	3,390	9	9	53.33
19	41	m	3,550	9	10	46.33
20	38.5	m	3,400	7	9	48.33
21	40	f	3,185	5	9	54.67
22	39.5	f	2,590	9	10	56.33
23	40	m	3,360	9	10	60.33
24	40	f	3,605	9	10	51.00
25	39.5	f	2,900	8	10	56.33
26	40	f	3,025	8	10	70.33
27	39.5	m	3,520	7	9	81.33
28	41	m	3,175	8	9	54.00
29	38.5	m	3,675	8	9	70.00
30	39.5	f	3,080	9	10	64.67
31	40	f	3,710	9	10	45.33
32	41	m	3,125	8	10	50.00
mean	39.7		3,206.56			
SD	0,9					

GA, gestational age; f, female; m, male; PSG, polysomnogram; SD, standard deviation.

in a supine position, feeding, bathed and changed prior to beginning of the recordings. Ambient temperature was kept warm with a space heater. All recordings were performed in the morning.

The PS were performed on a 21 channel analogical EEG machine (Nihon Kohden), and consisted of 16 channels of EEG and 1 channel respectively for electrocardiogram (EKG), submentonian electromyogram (EMG), electro-oculogram (EOG) and abdominal respiratory monitoring. Paper speed was 15 mm/sec, with a time constant of 0.3 sec, sensitivity of 10 μV/mm and a high frequency filter of 70 Hz for the EEG. The electrodes were placed in accord the 10-20 sys-

Table 2. EEG graphic elements in each phase of the sleep-wake cycle.

Graphic element		Sleep-wake cycle phase								N	Total mean	p
		Quiet		Active		Transitional		Awake				
		N	Mean	N	Mean	N	Mean	N	Mean			
FST	BS	236	7.4±4.1	248	7.8±7.3	107	3.3±4.8	77	2.4±4.8	668	20.9±11.9	<0.0001
	L	55	1.7±1.9	25	0.8±1.3	24	0.8±1.0	7	0.2	111	3.5±2.9	0.0005
	R	23	0.7±1.2	8	0.3±0.6	8	0.2±0.6	4	0.1	43	1.3±1.9	0.0002
	Total	314	9.8± 5.4	281	8.8±7.8	139	4.3±5.5	88	2.8±5.2	822	25.7±12.9	<0.0001
ASD	BS	15	0.5±0.6	44	1.4±1.6	17	0.5	5	0.2	81	2.4±2.3	<0.0001
	L	3	0.1±0.3	3	0.1	2		0		8	0.3±0.7	0.38
	R	0		1		1		1		3	0.1	0.99
	Total	18	0.6±0.7	48	1.5±1.7	20	0.6±1.0	6	0.2±0.5	92	2.9±2.4	0.0001
ASD/FST	BS	10	0.3±0.7	41	1.3	8	0.3±0.6	4		63	1.8±2.6	0.0008
	L	1		1		1		0		3	0.1	-
	R	1		0		0		0		1		-
	Total	12	0.4±0.8	42	1.3±2.3	9	0.3±0.6	4		67	2.1± 2.7	0.0014
	Total	106	3.3±3.6	55	1.7±2.3	41	1.3±2.4	3	0.1±0.4	206	6.4±5.9	

N, number of graphic elements; FST, frontal sharp transient; ASD, anterior slow dysrhythmia; ASD/FST, anterior slow dysrhythmia and frontal sharp transient; BS, bilateral and synchrony; L, left; R, right; p, Kruskal-Wallis test ($p \leq 0.05$).

tem as modified for NB[21]. The montages used followed internationally accepted standards for the neonatal period. The state of NB and all movements during the exam were recorded by a technician.

Sleep stages were classified (active, quiet and transitional) and only tracing containing a complete sleep-wake cycle, with active and quiet sleep, but not necessarily transitional sleep and/or awake samples[21] were selected for study. A minimum of four physiological variables, together with behavioral observations, were necessary to establish a new sleep stage[22]. EEG was mandatory to provide an adequate score for each sleep phase.

The mean duration of the recording was 57.45±9.73 minutes. Recording was interrupted after 35.33 minutes in one case (patient 15) due to the occurrence of bradycardia; however, the subject fulfilled all the inclusion criteria and was considered part of the study group (Table 1).

The total numbers of FST and ASD, as well as their association from, were quantified according to lateralization (right, left or bilateral and synchronous) in each stage of the sleep-wake cycle. Their density (number of FST per minute of sleep stage), type of presentation (isolated, burst) and morphology were also observed.

Statistical analyses – Data were grouped into different variables and analyzed using the Kruskal-Wallis tests. Distribution of variables was considered asymmetrical, with the level of significance considered as $p<0.05$. Each variable was also analyzed individually using histograms, and those with a normal distribution are presented using mean values and standard deviation (SD). The variables with asymmetrical distribution are presented using the median, minimum and maximum values[23].

RESULTS

All EEG recordings comprised a total of 1,839.33 minutes with total sleep duration of 1,567 minutes. Quiet sleep (QS) occupied 38.52% of total sleep time, whereas active sleep (AS) constituted 47.40% and transitional sleep (TS) 14.08% of total sleep time.

The total number of FST was 778 (25.6 per exam), of which 133 (16.75%) were unilateral (UL) (4.3 per exam). Distribution according to circadian cycle was as follows: 295 (37.9%) during quiet sleep, 273 (35.1%) in active sleep, 128 (6.5%) in transitional sleep and 82 (10.5%) in wakefulness. In quiet sleep there were 225 bilateral and synchronous (BS) and 70 unilateral sharps, whereas active sleep harbored 243 BS and 30 UL. Transitional sleep showed a total of 103 BS and 8 UL and in wakefulness 74 BS and 8 UL could be found. FST were counted individually in each sleep phase, being present during QS in all tracings. FST, bilateral and synchronous (BS-FST) and lateralized FST showed a higher frequency during QS ($p<0.05$) (Table 2).

Total ADS were more frequent during AS. Left side lateralized ASD was found during QS in three EEG. Right side lateralized ASD was found during AS in one recording. They were seen during TS in 12 recordings, being unilateral in only two EEG (1 at left, 1 at right). Total BS-ASD were more frequent during active sleep.

Frontal sharp waves together with anterior slow dysrhythmia (FST/ASD) were found in eight recordings during QS, ranging from 1 to 3 graphic elements in each tracing. Lateralized FST/ASD was observed in two recordings (1 at left, 1 at right). A total of 16 recordings disclosed FST/ASD during active sleep, FST/ ASD ranging from 1 to 9 in each recording. During TS, a total of 9 FST/ASD was found in seven recordings, ranging from 1 to 3 per individual recording. In one recording only left lateralized FST/ASD was observed during TS. During wakefulness, only four FST/ ASD were found, in three different recordings, all being BS.

The proportions per minute were as follows: in quiet sleep there were BS 1/2 min 40 sec, UL 1/8 min 20 sec; in active sleep BS 1/ 3 min, UL 1/23 min 30 sec; transient sleep BS 1/ 2 min 10 sec, UL 1/8 min 40 sec and in wakefulness BS 1/3 min 40 sec and UL 1/34 min.

DISCUSSION

FST can be considered an electroencephalographic pattern related to maturity are generally are more prevalent in term or near term babies and should disappear around 44-45 weeks of gestational age. Monod[3] described the appearance of FST at the beginning of quiet sleep and found it was quite rare in active sleep. Later, Arfel[5] also analyzed the dynamic of FST during sleep stages and described it in the beginning of sleep and in the transition from active to quiet sleep. Our results are consistent with Arfel[5] who showed an increase of FST in quiet sleep newborn. The total amount of FST and unilateral FST (right or left) were more frequent in QS and BS-FST did not correlate with any sleep phase. However, a trend has been found towards more frequent BS-FST during AS[5].

Our results showed an increased density of FST in quiet sleep of the neonatal. FST are abundant in QS, within *tracé alternant,* and in indeterminate sleep[3,24-26]. Both the total amount of FST and unilateral FST (right or left) were more frequent in QS. Bilateral and synchronous FST did not correlate with any sleep phase, however, they shown a trend to be more frequent during AS in accord to Arfel[5], with whom our results consistent.

The first studies on FST failed to prove a connection between such graphic elements and disease[3,5]. Arfel[5] studied the dynamics of FST in 110 newborns and infants. He found that pathological states did not increase the occurrence of those FST since most of them were recorded in children either normal or suffering from minor disturbances. Scher[13] described the incidence of sharp waves in a healthy neonatal population, may have higher numbers of sharp wave transients despite the absence of encephalopathic patterns with normal neurodevelopment. Nunes[8] suggested that perinatal neurological disease may cause a delay in central nervous system maturation and may also hinder the electroencephalographic expression of appropriated EEG features as FST. In another study that author, comparing hypoglycemic NB and normal controls suggested an increased density FST in all sleep stages, in NB small for their GA[15]. FST are physiological elements of the NB sleep and the most consistent explanation to classify them as a normal paroxysmal transient is because they also appear in normal newborn and are generally absent in extremely abnormal EEG[3,5].

We found that ASD and ASD/FST, in each sleep phase, exhibits a greater density during AS. Bilateral and synchronous ADS displays a higher incidence in AS and, comparing brain sides, it was more frequent on the left side, as already described by Nunes[15]. It is interesting to note that FST are more prevalent in QS, but when it is associated with ASD are in AS.

FST, first described occurring bilateral and synchronous, asynchrony of FST is not uncommon in normal subjects. Our results showed FST asynchronous in healthy full term newborns, but it is normal depended of FST density or proportions per minute. Their unilateral appearance should not necessarily be considered abnormal as well.

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