343

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INCIDENCE AND PROGNOSTIC VALUE OF SPINDLES IN POST-TRAUMATIC COMA

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Spindle activities resembling those in normal slow wave sleep have been shown to occur in the diurnal EEGs of post-traumatic comatose patients (Chatrian et al. 1963; Silverman 1963; Cadilhac et al. 1966; Naquet et al. 1967; Bricolo and Turella 1973; Lorenzoni 1975; Stockard et al. 1975; Rumpl et al. 1979). Spindles were reported as 'spindle coma' by Courjon (1962) and studied in detail by Chatrian et al. (1963). Silverman (1963) observed the occurrence of spindles in comatose patients of various etiologies and a distortion of the typical morphology with deepening coma. The incidence of spindles in post-traumatic coma varied between 14% in the cases of Steudel et al. (1979), 27% in the cases of Lorenzoni (1975), 32% in the patients of Bricolo and Turella (1973), 47% in the cases of Silverman (1963), 49% in the cases of Courjon et al. (1971) and 67% in the cases of Bergamasco et al. (1968), who also studied long-lasting night records. Spindle activity was found to be associated with a relatively good prognosis (Chatrian et al. 1963; Silverman 1963; Vigouroux et al. 1964; Lücking 1970; Courjon et al. 1971; Stockard et al. 1975; Rumpl et al. 1979) but the prognostic significance is not generally accepted (Lorenzoni 1975; Hughes et al. 1976; Hansotia et al. 1981). This study correlates spindle activity with different categories of outcome in order to determine the incidence and the prognostic value in post-traumatic comatose patients.

Case material and Methods

A group of 80 comatose patients aged 9–73 years was investigated between September 1977 and February 1981. All had closed head injuries and demonstrated signs of brain stem dysfunction. The patients underwent the usual neuroradiological examinations (CT scan, angiography) and appropriate conservative or operative management in the intensive care unit. The study excludes patients under barbiturate anaesthesia for treatment of intracranial hypertension. Furthermore all patients suffering from severe pulmonary, hepatic or renal complications were excluded. A total of 133 EEGs in 80 patients were analysed. Seventy EEGs were taken in the acute stage of coma (within the first 2 days after brain injury). Sixty-three EEGs were recorded in a prolonged comatose state (days 3–12 after brain injury).

According to Gerstenbrand and Lücking (1970) the patients were classified neurologically in stages 1–4 of the midbrain syndrome (MBS) and stages 1 and 2 of the bulbar brain syndrome (BBS, Table I). These stages characterize the well-known rostro-caudal deterioration in patients with supratentorial lesions and secondary brain stem involvement (McNealy and Plum 1962; Plum and Posner 1966). After Maciver et al. (1958) a primary brain stem lesion can be suspected if the neurological signs do not fit the classical stages of rostro-caudal deterioration, i.e., the relatively intact optomotor reactions are in contrast to decerebrate posturing and respiratory abnormalities. This assumption was corroborated by the normal or slightly abnormal CT scan findings in such cases (Rumpl et al. 1982a). The neurological signs in prolonged coma are related to those seen in the acute stage of coma. Patients with good outcome will usually change to an earlier stage of the midbrain syndrome, indicating the decrease of brain stem involvement. In contrast, patients with moderate or bad outcome remain unchanged or show signs of increasing rostro-caudal deterioration. In these cases the vegetative parameters are frequently in-

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TABLE I

Clinical signs in post-traumatic comatose patients at the different stages of the midbrain syndrome (MBS) and bulbar brain syndrome (BBS). Modified from Gerstenbrand and Lücking (1970).

	MBS 1	MBS 2	MBS 3	MBS 4	BBS 1	BBS 2
Spontaneous limb postures	Non-stereotyped movements in the arms and legs	Non-stereotyped movements in the arms Extension of the legs	Decorticate posturing	Decerebrate posturing	Flaccidity	Flaccidity
Motor response to pain	Non-stereotyped withdrawal of the limbs	Non-stereotyped withdrawal of the arms Extensor response of the legs	Decorticate response	Decerebrate response	Decerebrate response	No response
Eye position	Roving movements	Roving more irregular movements	Immobile straight ahead	Immobile divergent	Immobile divergent	Immobile divergent
Pupil size and reaction	Normal Reacting	Normal small Reacting	Small Small range of contraction	Enlarged Small range of contraction	Large Unreacting	Large Unreacting
Respiration pattern	Normal	Cheyne-Stokes	Cheyne-Stokes Rapid regular hyperventilation	Regular hyperventilation	Ataxic	No respiration

fluenced by increasing overactivity of the sympathetic nervous system (Avenarius and Gerstenbrand 1977; Hörtnagl et al. 1980). Our patients were comatose for at least 7 days; most of them opened their eyes 2 or 3 weeks after injury. According to Jennet and Bond (1975) the outcome of patients was classified in good recovery, moderate or severe disability and brain death. The category 'severe disability' includes patients at an apallic (vegetative) state.

A detailed classification of EEG patterns was given in previous papers (Rumpl et al. 1979; Rumpl 1982b). Special attention was paid to spindle activity, which was classified as 'typical' and 'atypical.' 'Typical' spindles (TSP) were easily recognizable well organized widespread bursts of 12–14 c/sec activity. 'Atypical' spindles (ASP) were of lower frequency (6–11 c/sec), or of distorted form (Silverman 1963) and sometimes hardly separable from superimposed fast activity. Both types of spindle were generally accompanied by diffuse slowing. Asymmetries of spindles were noted, usually showing a close correlation with unilateral hemisphere lesions in the CT scan.

Gauze covered silver electrodes were routinely placed in pairs on the left and right frontal, central, parietal and occipital, and anterior and posterior temporal areas. Bipolar longitudinal and transverse montages were used. Except in cases with low voltage cerebral activity a high frequency filter of 30 Hz and a time constant of 0.3 sec were used.

Results

General observations

In patients with good recovery (N = 26) spindles were seen in all EEGs recorded during the acute stage of coma (100%). ASP (8%) and asymmetries of spindle activity (12%) were rarely observed in these cases. In prolonged coma spindles occurred in 44% of patients with good outcome, demonstrating ASP in 11% and asymmetry in 25% of spindle EEGs. The EEGs of patients with moderate disability outcome (N = 10) showed spindles in 90% of all records during the acute stage of coma. Although the number of patients was small an increase of ASP (33%) and asymmetry (33%) was noted. In prolonged coma only 7 EEGs were

analysed. There was a remarkable increase of ASP (50%). The EEGs of patients developing severe disability showed spindles in 61% of all cases (N = 18). ASPs were found in 45%, asymmetry in 63% of spindle EEGs. Prolonged coma patients, later severely disabled, showed only ASP and the percentage of spindles decreased to 24%. Asymmetries were seen in 40%. Patients who died from brain death within 2 weeks after brain injury (N = 16) showed spindles in 56% in the acute stage of coma. Asymmetry of spindles was seen in 88% and ASP in 44% of spindle comas. In prolonged coma (N = 17) spindles were only seen in 2 cases (12%) and in both were asymmetrical. With worsening of outcome there was a steady decrease of spindle activity in the acute stage of coma, accompanied by an increase of ASP and of asymmetry. In prolonged coma spindles were less frequently seen than in the acute stage of coma with a similar decrease corresponding to the outcome as seen in the acute stage. The percentage of ASP and asymmetries increased as in acute coma. The overall incidence of spindles in the acute stage of coma was high (91%) but showed a remarkable decrease (30%) in prolonged coma (Table II).

Special observations

Good outcome category. Reactivity of the alerting type was seen in 21 patients in acute coma, who also showed spindles. Two patients had reactivity of the blocking type (Li et al. 1952); in 1 patient disappearance of spindles was the only change after acoustic or painful stimulation. Two unreactive patients showed ASP. Alternating EEG patterns were a common finding. Unilateral slowing was seen in 5 patients. In prolonged coma there was a clear decrease of TSP, while reactivity and alternating EEG patterns were nearly unchanged. Reactivity was of the blocking type in 4 cases. A delayed response characterized by a slow change of low voltage alpha/theta activity to high voltage delta activity was seen in 2 cases. The others had reactivity of the alerting type (Fig. 1).

The CT scan was normal in 8 patients and showed mild diffuse brain oedema in 14 cases. Local contusional lesions of minor degree were seen in 6 patients. In 2 patients small intracerebral hematomas were confined to the left occipital or to the left frontal region. Severe diffuse brain oedema was present in 1 case. Blood was found in the interhemispheric fissure in 2 cases and in the third ventricle in 1 case. Small subdural hematomas were seen in 2 cases.

On neurological examination 4 patients belonged to midbrain syndrome (MBS) stage 1, 3 of them exhibiting lateralized signs. Sixteen patients

TABLE II

Incidence of spindles, form of spindles and asymmetries of spindle activity in different outcome categories. The percentages of atypical spindles and asymmetry of spindles remarkably increase with worsening of outcome. Spindles are seen in most cases in acute coma (within the first 2 days after injury) but show clear reduction in prolonged coma (days 3–12 after injury).

Outcome categories (N = number of patients and EEGs)	Acute coma							Prolonged coma						
	N	Spindles		Atyp. spindles		Asymmetry		N	Spindles		Atyp. spindles		Asymmetry	
		Total	%	Total	%	Total	%		Total	%	Total	%	Total	%
Good recovery	26	26	100	2	8	3	12	18	8	44	2	11	2	25
Moderate disability	10	9	90	3	33	3	33	7	4	57	2	50	1	25
Severe disability	18	11	61	5	45	7	63	21	5	24	5	100	2	40
Brain death	16	9	56	4	44	8	88	17	2	12	1	50	2	100
Total coma	70	64	91	14	22	24	33	63	19	30	10	53	7	37

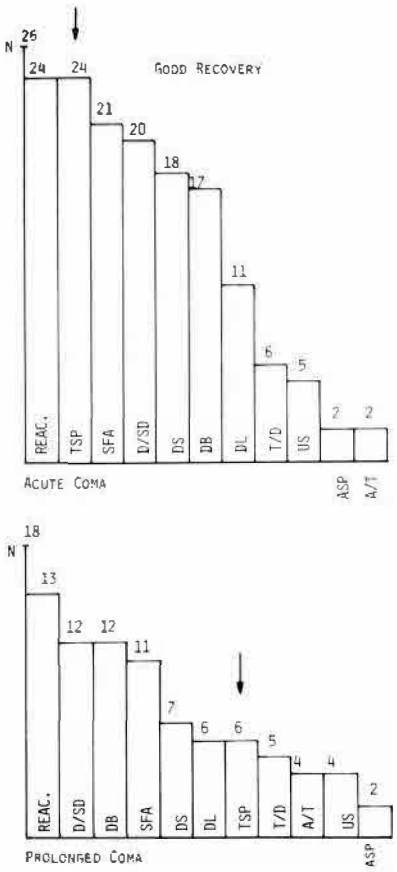

Fig. 1. The EEG patterns in acute and prolonged coma in patients with good recovery. Typical spindles (arrow) are seen in the majority of EEGs in acute coma, but are clearly reduced in prolonged coma. The variety of other EEG patterns is slightly depressed in prolonged coma. The records were listed under one or more of the following categories: A/T, predominant alpha and little theta activity; T/D, predominant theta and little delta activity; D/SD, predominant diffuse rhythmic and arrhythmic delta and subdelta activity; DB, delta bursts; DS, short runs of delta; DL, long runs of delta; TSP, typical spindles; ASP, atypical spindles; US, unilateral slowing; SFA, superimposed fast activity; REAC., reactivity; N, number of records and patients.

were judged as MBS 2; lateralization was found in 4 cases. Two patients of this group were classified as having primary brain stem injuries. Three patients were in MBS 3, one of them due to direct injury to the brain stem. Eight patients showed decerebrate posture, leading to the classification of MBS 4. In contrast to this alarming neurological finding the CT scan was normal or slightly abnormal (mild brain oedema) in these cases. Therefore a primary brain stem impact was thought to be the principle cause of coma. TSP could be seen in patients comatose due to primary and secondary brain stem lesions (Figs. 2a and 3a). The mean age of this group was 21 ± 10 years, varying from 9 to 54 years. Two patients were over 40.

Moderate disability category. Reactivity of the EEG was seen in 8 out of 10 patients in acute coma. The alerting type of reactivity after stimula-

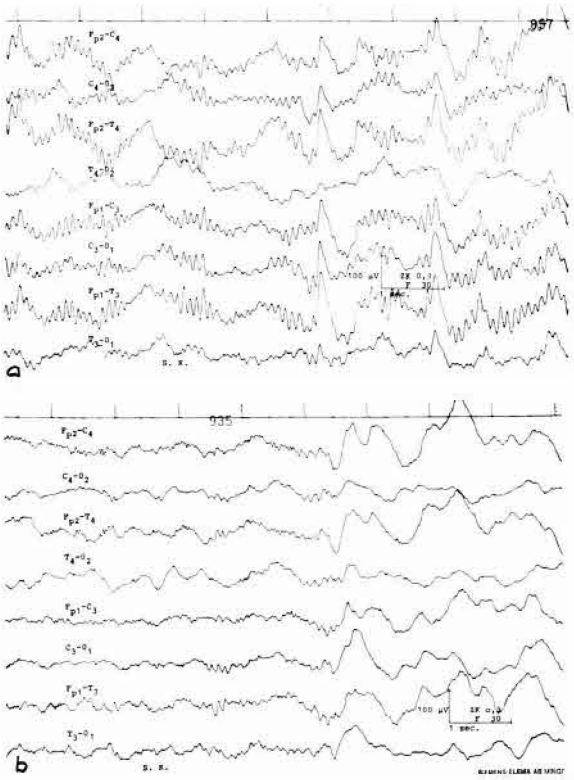

Fig. 2. a: EEG from a 23-year-old male patient in acute coma due to secondary brain stem dysfunction (classical midbrain MBS stage 2 without lateralization). Easily recognizable typical spindles, symmetrical over both hemispheres, accompanied by K complexes and diffuse slowing. CT scan: moderate brain oedema with scattered contusional areas in left fronto-temporo-parietal and right temporal regions. No signs of compression at tentorial level. Blood within the interhemispheric fissure. b: EEG from the same patient in prolonged coma. No spindles, superimposed fast activity and change to high voltage short and long delta runs (alternating pattern). No lateralized signs in the EEG. Outcome: good recovery.

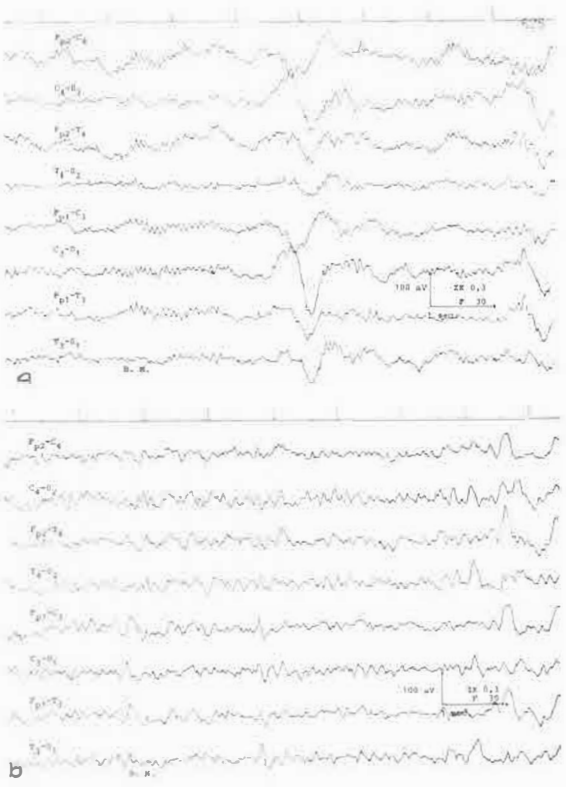

Fig. 3. a: EEG from a 20-year-old male in acute coma due to primary brain stem injury. Neurological signs of atypical midbrain syndrome stage 4 (decerebrate posture). Typical spindles, delta bursts, superimposed fast activity accompanied by diffuse slowing. CT scan: a normal CT scan indicates the primary brain stem involvement. b: EEG from the same patient in prolonged coma. Predominant alpha / theta activity, several delta waves, reactivity in form of blocking slow waves, no lateralized EEG signs. Rather characteristic EEG pattern for pontine lesions. Outcome: good recovery.

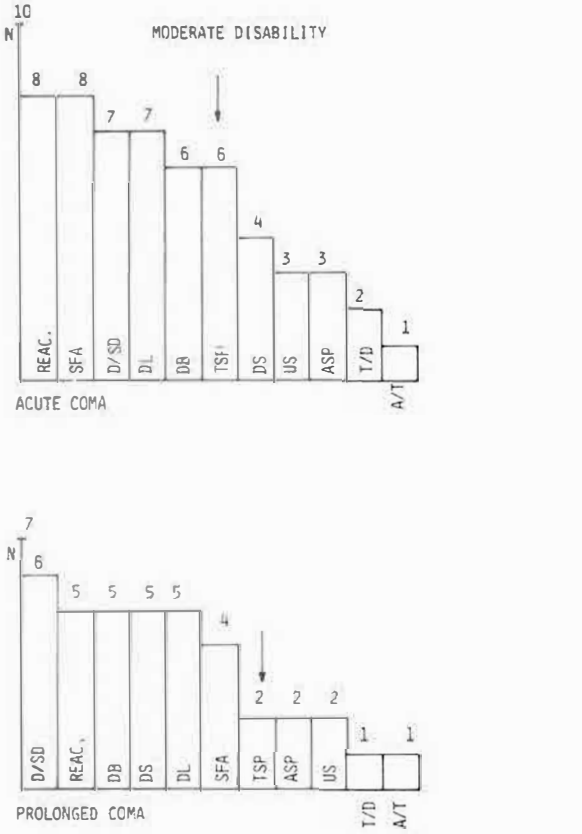

Fig. 4. The EEG patterns in acute and prolonged coma in patients with moderate disability outcome. Typical spindles (arrow) are frequently seen in acute coma and show reduction in prolonged coma. No dramatic change in other EEG patterns between acute and prolonged coma. Reactivity is closely related to the capacity for spindling. Observations hampered by small number of patients. Abbreviations as in Fig. 1.

tion was seen in 6 cases. In one spindleless EEG a reduction of amplitude of delta waves after stimulation was seen. Disappearance of spindles secondary to stimuli was found in one other case. Spindles showed a remarkable decrease in prolonged coma. Alternating EEG patterns were frequently seen and alerting responses in all cases (Fig. 4).

The CT scan revealed severe brain oedema in 5 cases and moderate oedema in one. One CT was normal. Extensive cerebral contusions were found in 3 patients. Epidural hematoma with signs of tentorial herniation, intracerebral haemorrhage at basal ganglia level, blood in the third ventricle and a small subdural hematoma were found in 1 patient each.

Three patients were rated MBS 2, two of them showing lateralizing signs. Four were rated MBS 3 and three MBS 4. One patient each of MBS 2 and MBS 3 and 2 patients of MBS 4 suffered from primary brain stem injuries and showed TSP. The mean age was 23 ± 10 years, varying from 12 to 41 years. Two patients were older than 30.

Severe disability category. Reactivity decreased in 10 out of 18 cases in the acute stage of coma. In 7 EEGs an alerting response was noted, three of

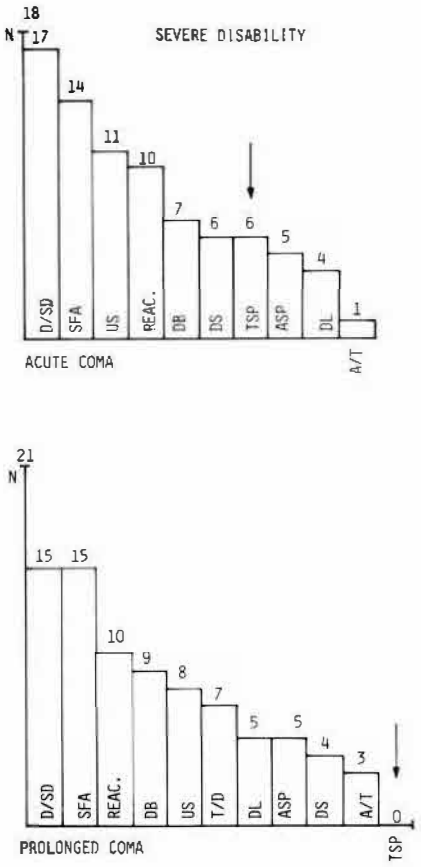

Fig. 5. The EEG patterns of patients with severe disability outcome in acute and prolonged coma. Note the decrease of typical spindles (arrow) in acute coma and the total loss of typical spindles in prolonged coma. Also reactivity is less frequently seen in these cases. General decrease in the variety of EEG patterns. Abbreviations as in Fig. 1.

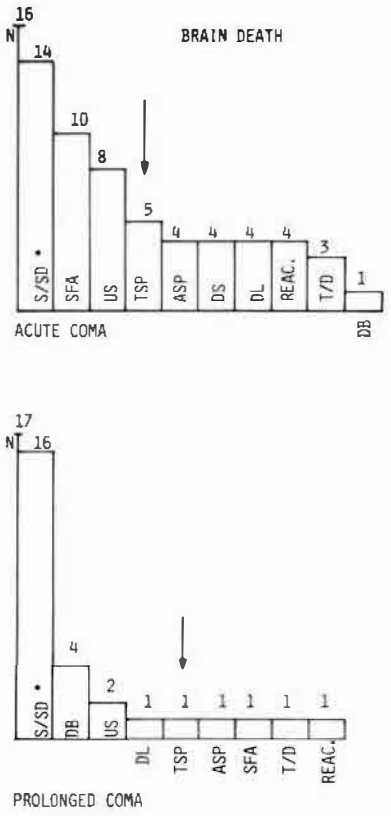

Fig. 6. The EEG patterns in patients who died from brain death within 14 days after brain injury. In acute coma typical spindles are rarely seen and are symmetrical only in 1 case. In prolonged coma typical but asymmetrical spindles are seen in 1 case. A similar decrease in reactivity. Poor variety of EEG patterns. Columns of delta/subdelta activity include 3 low voltage EEGs in acute coma, 7 low voltage EEGs and 4 isoelectric EEGs in prolonged coma. Abbreviations as in Fig. 1.

them showing asymmetry. A loss of spindles was seen in 2 patients after stimulation, without further changes. In 1 patient a reduction in amplitude of delta/subdelta waves was observed. In 7 patients reactivity was seen in EEGs otherwise characterized by TSP and ASP. Unilateral slowing was present in 11 cases. In prolonged coma the most significant finding was the total loss of TSP (Fig. 5).

The CT scan demonstrated severe brain oedema in 6 patients, 4 of whom had signs of tentorial herniation. Moderate brain oedema was present in 11 cases, slight brain oedema in 4 cases. One CT was normal. An epidural hematoma occurred in 4 cases. Large areas of contusion were seen in 7 patients. Two patients had large subdural hematomas and one had blood in the third ventricle.

Five out of 14 patients with MBS 4 had primary brain stem injuries. Six patients were rated MBS 3, one MBS 2. Seven patients died from extracerebral complications 1–6 months after brain injury; they had shown no significant signs of recovery. The mean age of the groups was 28 $\pm$ 12 years, varying from 15 to 51 years. Eight patients were older than 30.

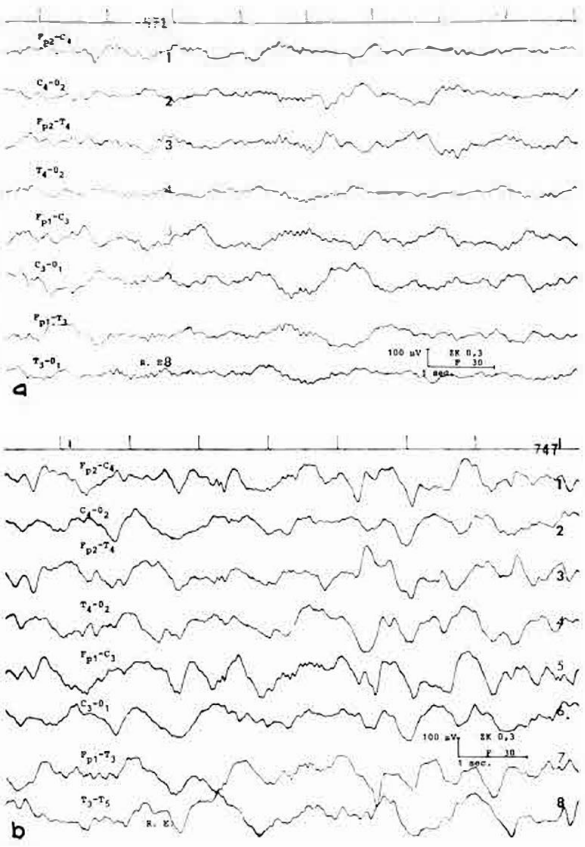

Fig. 7. a: EEG from a 17-year-old female in acute coma due to secondary brain stem involvement (classical midbrain syndrome stage 4). Atypical (mildly abnormal) and asymmetrical spindles. Spindles are better seen on the left. Slight reduction in amplitudes of slow waves on the right. CT scan: areas of local brain contusion at basal ganglia level on both sides. Small haemorrhagic lesion in the posterior part of the left internal capsule. Signs of tentorial compression. Blood in the third ventricle. b: EEG from the same patient in prolonged coma. Atypical (severely distorted) spindles in the left frontal region. Spindles are hardly recognizable and can only be detected from knowledge of the previous EEG (a). ●utcome: brain death.

Brain death category. Reactivity of the alerting type was seen in 4 out of 16 EEGs in the acute stage of coma. No other pattern of reactivity could be observed. All EEG patterns reduced in acute coma showed further reduction in prolonged coma. Low voltage EEGs were seen in 3 cases in acute coma. In prolonged coma the number of low voltage EEGs increased to 7 and an isoelectric EEG was found in 4 cases. In rare cases remnants of spindle activity could be noted (Figs. 6 and 7a, b). Two patients showed spindles that were asymmetrical and in one case they were severely distorted.

The CT scan showed severe brain oedema in 12 cases, moderate oedema in 2 and slight oedema in 3. One patient had an epidural, 2 had subdural hematomas. Large contusional areas with small hematomas were observed in 4 patients. Blood within the brain stem was seen in 3 patients and in the fourth ventricle in 4 cases.

Thirteen patients were rated MBS 4 and 1 patient MBS 3; 2 patients had bulbar brain syndrome (BBS) stage 1. Three patients had primary brain stem injuries. All patients died from brain death within 14 days after injury. The mean age of the group was 34 ± 19 years, varying from 14 to 73. Seven patients were older than 30, 6 older than 40.

Discussion

In cases of traumatic coma Chatrian et al. (1963) reported EEG patterns otherwise considered typical of sleep. Spindle activity was studied in more detail by Silverman (1963). He found it difficult to recognize spindles with deepening of coma, in which their distortion and gradual disappearance was noted. Our findings confirm these statements. The percentage of ASP increased with progression of coma and thereby indicated a poor outcome. We also found the increase of asymmetry of spindle activity to be related to the worsening of outcome. Asymmetries of spindle activity were accompanied by unilateral slowing (Rumpl et al. 1979). These changes indicate a hemispheral lesion, corroborated by the CT scan findings. Generally there were good correlations between the symmetry and form of spindles, clinical examination and CT scan findings. Exceptions were seen in cases of primary brain stem injuries. Despite decerebrate posturing many of them recovered well, while the others died or survived in a state resembling a post-traumatic locked-in syndrome (Britt et al. 1977). Chatrian et al. (1963) described decerebrate rigidity in 8 of their 11 patients with spindles and good recovery. In these cases one might assume impairment of the midbrain and

brain stem but undisturbed thalamic structures (Grossman 1949; Jasper and Van Buren 1953; Hughes et al. 1972; Bricolo and Turella 1973; Steudel et al. 1979). In cases with supratentorial lesions spindle activity suggests relatively intact cortical functions and a chance for good recovery (Silverman 1963). There were no significant differences in spindle activity in the different outcome categories, if primary and secondary brain stem lesions were compared. On the other hand one should consider that primary brain stem injuries rarely exist alone (Mitchell and Adams 1973) and also that the hemispheres are frequently involved. This may especially be true in patients with bad outcome.

The incidence of spindles varied between 14 and 67% (Steudel et al. 1979; Bergamasco et al. 1968). This fact might be responsible for the doubt of any prognostic value of spindles (Lorenzoni 1975; Hughes et al. 1976; Hansotia et al. 1981). Our findings demonstrate that the observation of spindles largely depends on the point in time of the EEG recording. Within 2 days after brain injury (acute coma) the majority of EEGs showed spindles. Chatrian et al. (1963), Courjon et al. (1971), Steudel et al. (1979) but also Hansotia et al. (1981) found spindle activities when the records were made within 2 days after trauma. The percentage of spindles markedly decreased between days 3 and 12 after injury and then was closely related to the percentages reported in the literature. In our cases the decrease of spindles not only indicated the deepening of coma, but more frequently the change to a prolonged comatose state. In this case the loss of spindles was of less prognostic significance when other EEG signs of favourable outcome — reactivity, alternating patterns, high voltage and symmetry of activities — remained unchanged. Our experience has been consistent with the results of previous papers. Courjon et al. (1971) observed the decrease of spindles 48 h after injury in their patients with good recovery. Sustained reactivity represented a favourable prognostic sign in these cases. The absence of spindles in deep stages of coma was reported by Vigouroux et al. (1964), who further found a decrease of spindles in prolonged coma. The disappearance of frequencies of the 12–14 c/sec range between days 3 and 5 after trauma was one of the most striking findings of Bricolo et al. (1978), using compressed spectral array in long-term EEG monitoring. A lack of spontaneous variability was seen and the EEG tended to be 'monotonous' (Bricolo et al. 1978).

In cases with severe disability outcome the total loss of TSP was an impressive finding. This observation was also made in patients developing an apallic (vegetative) state (Rumpl 1980). It should be noted that the brain's capacity for spindling is closely related to its capacity for EEG arousal, which are both partially lost in the late stages of MBS and BBS, as well as in prolonged coma. The disappearance of spindles in prolonged coma suggests that spindle activity cannot predict the outcome in prolonged coma. On the other hand, if spindle activity is present, asymmetry and distortion will be of prognostic value. ASP and asymmetries significantly increase in patients with bad outcome.

In contrast to prolonged coma spindle activity is seen in most patients in acute coma and is of high prognostic value. The percentage of spindles decreases and their distortion and asymmetry steadily increase with worsening of the outcome. In the early stages of MBS due to secondary brain stem involvement TSPs point to a good outcome. This is also true in coma due to primary brain stem lesions. There seems to be no significant influence of small contusional areas in CT scans on spindle activity. More severe hemispheral lesions lead to distortion, asymmetry and lack of spindles, reflecting the severity of brain dysfunction in acute coma. Barbiturate anaesthesia may be used in the treatment of intracranial hypertension; by this therapy EEG activity and neurological signs are severely altered. In the light of our observations we advocate early EEG recording before barbiturates are given.

Summary

One hundred and thirty-three EEGs were analysed from 80 comatose patients with signs of brain stem impairment due to head/brain injury. Seventy EEGs were taken in acute coma on day 1

or 2 after brain injury. Sixty-three EEGs were recorded in prolonged coma 3–12 days after brain injury. Brain stem involvement was divided by neurological signs and by CT scan into secondary lesions due to supratentorial mass displacement and primary lesions due do direct violence to the brain stem. Different EEG patterns were observed, but spindle activity was of special interest. Spindles were classified as typical (easily recognizable, well organized, 12–14 c/sec activity) or atypical (hardly recognizable, distorted form, 6–11 c/sec activity). Furthermore, asymmetries of spindles were noted. The spindles and their alterations were related to different stages of outcome.

Spindles were seen in 91% of the EEGs in acute coma and in 30% in prolonged coma. In acute coma due to secondary brain stem involvement a good outcome was heralded by the occurrence of typical symmetrical spindles combined with early stages of secondary brain stem impairment at neurological examination. In cases of primary brain stem involvement typical spindles also suggested a good prognosis despite the observation of serious clinical signs (decerebrate posturing). The percentage of spindle activity decreased, and distortion and asymmetry of spindles increased with the worsening of outcome. Severe intracerebral lesions (confirmed by clinical and CT scan examinations) led to distortion, asymmetry and finally disappearance of spindles. In prolonged coma spindle activity was markedly reduced regardless of the final outcome. When spindles were present atypical and asymmetric forms significantly increased in patients with bad outcome. There were no significant differences in spindle activity in the different outcome categories, if primary and secondary brain stem lesions were compared.

Résumé

Incidence et valeur pronostique des fuseaux dans le coma post-traumatique

Cent trente-trois EEG ont été analysés chez 80 patients comateux avec signes d'atteinte du tronc cérébral, à la suite de blessures crâniennes et cérébrales. Soixante-dix EEG furent recueillis en coma aigu, au jour 1 ou 2 après le traumatisme crânien. Soixante-trois EEG ont été enregistrés sous coma prolongé, 3–12 jours après le traumatisme. L'atteinte du tronc cérébral était distinguée, à partir des signes neurologiques et du CT scan, en lésion secondaire liée au déplacement de la masse supratentorielle, et en lésion primaire due à un choc direct sur le tronc. Divers patterns EEG furent observés, mais l'activité en fuseau s'est montrée d'un intérêt particulier; ces fuseaux ont été classés comme typiques (activité à 12–14 c/sec, aisément reconnaissable, bien organisée) ou atypiques (activité à 6–11 c/sec, mal reconnaissable, et déformée). En outre, l'asymétrie de ces fuseaux était également considérée. Les fuseaux et leur altération ont été mis en rapport avec l'évolution du coma.

Les fuseaux furent observés dans 91% des EEG du coma aigu, et 30% de coma prolongé. En coma aigu avec une atteinte secondaire du tronc, des fuseaux symétriques, typiques, associés — à l'examen neurologique — aux stades précoces d'une implication secondaire du tronc, laissaient présager une évolution favorable.

En cas d'atteinte primaire du tronc, des fuseaux typiques étaient également un pronostic favorable, malgré l'existence de signes cliniques sérieux (posture de décérébré). Le pourcentage de fuseaux diminuait en revanche, avec plus de distorsion et d'asymétrie, lorsque l'issue était mauvaise.

Des traumatismes intracérébraux sévères (confirmés par la clinique et le scan) s'accompagnaient de distorsion, d'asymétrie et, finalement, d'une disparition des fuseaux. En coma prolongé, l'activité en fuseau était nettement réduite, quelle que soit l'issue finale. Lorsque les fuseaux étaient présents, des formes atypiques et asymétriques étaient significativement plus nombreuses chez des patients à évolution défavorable. Mais il n'y avait pas de différence significative de l'activité fuseau, selon l'issue, lorsque les atteintes primaires et secondaires du tronc étaient comparées.

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