Primitive motor patterns and stereotyped movements. A comparison of findings in early childhood and in the apallic syndrome.

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The central nervous system can be regarded as an information processing apparatus consisting of a complex set of brain mechanism. The nervous system receives, conducts, compares and generates messages in order to transform them into motoric actions as movement and speech (Fig. 1).

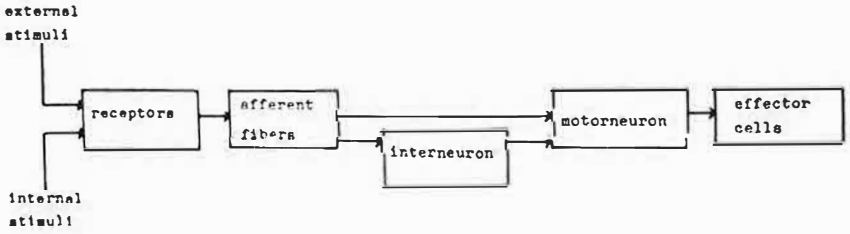

Figure 1 : Information flow in the nervous system

In the developing human brain the operations of the nervous system at each developmental stage are adapted to the internal and external conditions of the individual organism (11).

Neural mechanisms is defined as a network of neurons and synapses which form pathways for specific nervous activity. Identical neural mechanism can be involved in various functional expressions of nervous system activity. Three types of neural mechanism can be distinguished (Tab. 1).

First, there are neural mechanisms, which are present at a very early stage of the infants' development. They are regarded as a prerequisite for further development. Examples are the neural mechanisms for food intake, the vestibular apparatus, the neural mechanisms for the visual and acoustical perception and the mechanism for the generation of an adequate muscle tonus. They can be labelled as "basic" neural mechanism.

Second, there are those neural mechanisms, which gradually merge into larger and more complex actions, or seemingly disappear completely and reappear at a later phase of the development. These mechanisms seem to mature according to a rather regular sequence. A general weakening of higher inhibitory and regulatory centres in the brain apparently allows numerous deve-

TABLE 1: THREE TYPES OF NEURAL MECHANISMS (N.M.)

1) n.m.:	PRESENT AT EARLY STAGE OF INFANTS DEVELOPMENT (FOOD INTAKE, VESTIBULAR APPARATUS, VISUAL AND ACOUSTICAL PERCEPTION)
2) n.m.:	WITH MATURATION IN A REGULAR SEQUENCE AND THE PHENOMENON OF REAPPEARANCE (REAPPEARANCE OF INFANTILE RESPONSE LIKE REACTIONS)
3) n.m.:	MATURING INDEPENDENTLY AND BECOMING LINKED TOGETHER (THE DEVELOPMENT OF VOLUNTARY GRASPING)

lopmental, foetal or primitive responses present in foetal and nursling life to reassert themselves, e.g., reappearance of infantile response - like reactions in several diseases of the central nervous system.

Third, there are the mechanisms which mature more or less independently and become linked together at a particular moment, which results in differentiated motor patterns, e.g., the development of voluntary grasping (13).

It is still unanswered whether maturation and organization of neural mechanisms take place in accordance with a fixed time schedule or the various neural mechanisms mature with wide overlap or even synchronously. Finally, there may exist a combination of these two processes.

Both research reports and clinical experiences support the view that neural mechanisms do not disappear definitely and totally. It is a well known clinical experience that in cases of severe brain damage motor patterns closely resembling patterns of infancy may reappear. Thus we may assume that some neural mechanisms seem to disappear during ontogeny because they become dominated or covered by other mechanisms, without losing their characteristics. This explaines the reappearance at a later age under specific circumstances (10).

TOUWEN presented 1976 a selection of items including motor patterns, which are potentially relevant for a comprehensive neurological examination of healthy infants. A statistical analysis of the developmental course of a series of items is demonstrated which are used in neurological and developmental assessment during the first year of life (11). The first group contains those items which do not show any substancial changes from birth onwards. It may conclude that their neural mechanisms are sufficiently mature a birth. The second group includes items which develop rapidly what means that their neural mechanism mature quickly. Group 1 and 2 represent the neural mechanism which must mature before other mechanism can manifest themselves. But this does not imply that neural mechanism cannot develop when the neural mechanism underlying visual functions, for instance, are deficient.

The items of group 3 (Table 2 a) would appear to be of clinical significance in so

ITEMS WHICH SHOW FAIR DIFFERENTIATION AND AN EVIDENT DEVELOPMENTAL SEQUENCE

OBSERVATION OF POSTURE AND MOTILITY

SPONTANEOUS POSTURE OF ARMS AND LEGS
SPONTANEOUS MOTILITY OF ARMS AND LEGS
TYPE OF VOLUNTARY GRASPING
COORDINATION OF UPPER EXTREMITIES
LOCOMOTION IN PRONE POSITION
ROLLING OVER SUPINE-PRONE
ROLLING BACK PRONE-SUPINE

SITTING UP
STANDING UP
WALKING

REACTION AND RESPONSES

ROOTING REFLEX
ASYMMETRIC TONIC NECK RESPONSE
PALMAR GRASP REFLEX
OPTICAL PLACING REACTION OF HANDS
OPTICAL PLACING REACTION OF THE FE
FOOT SOLE RESPONSE
ACOUSTICAL ORIENTING
THE MORO REACTION

Table 2 a (TOUWEN, 1976)

ITEMS FOR WHICH A DEFINITE DEVELOPMENTAL SEQUENCE COULD NOT BE ESTABLISHED

OBSERVATION OF POSTURE AND MOTILITY

SPONTANEOUS POSTURE OF THE HANDS
POSTURE OF HEAD AND TRUNK DURING PRONE SUSPENSION (LANDAU)

REACTIONS AND RESPONSES

REACTION TO TACTILE STIMULATION OF THE DORSUM OF HANDS
PALMOMENTAL RESPONSE
KNEE JERK
ANCLE CLONUS
PLANTAR GRASP
MAGNET RESPONSE
CROSSED EXTENSION RESPONSE
TACTILE PLACING OF THE FEET
BAUER REACTION
GALANT RESPONSE
SCHALTENBRAND REACTION
THREAT REFLEX

Table 2 b (TOUWEN, 1976)

far as they reflect the qualitative development of neural mechanisms. These however show a developmental course which may vary widely interindividually. It is obvious that the qualitative appraisal of those items is important for the evaluation and coaching of treatment in cases of an apallic syndrome. The items of group 4 (Table 2 b) seem hardly useful as their variability is large and their developmental course is excessively protracted.

While there seems to be a time sequence in the maturation of the brain mechanisms of the items in group 1 and 2, in the case of many items of groups 3 and 4 there seems to be a contemporarly maturation of brain mechanisms which may achieve expression consecutively (8). The dissolution of the palmar grasp reflex, e.g., takes place at about the same time as the beginning of voluntary grasping, which might imply that a dissolution of the palmar grasp reflex is a prerequisite for the development of voluntary grasping. Palmar grasp reflex and the initial type of voluntary grasping may coincide (9).

The newborn infant can be labelled as an orovestibular human being with neural functions integrated at a mesodiencephalic level. The further evolution is characterized by the formation of a higher perceptive function system, the visual and acoustic system. Synchronously voluntary motor patterns and speech functions develop while primitive motor patterns disappear. PEIPER presumed a mesodiencephalic level of brain development in newborns (11). A similar neurofunctional level is being under consideration for the apallic syndrome.

According to KRETSCHMER the apallic syndrome is characterized by loss of all cortical functions with release of autonomic

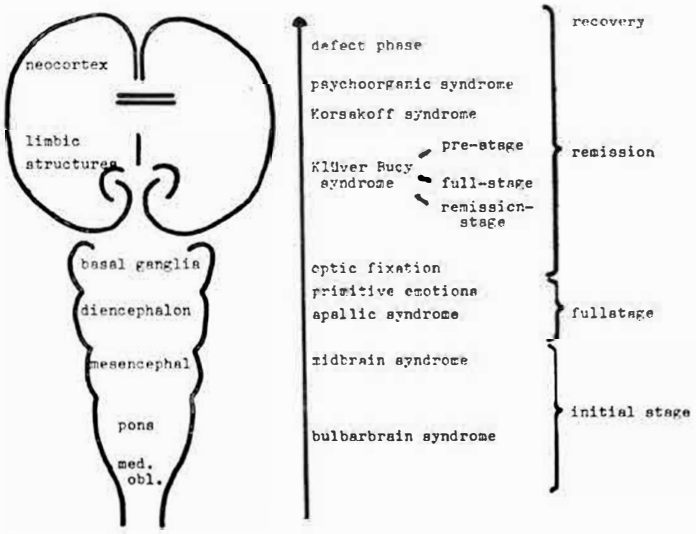

Figure 2: The different stages of an apallic syndrome in relation to different levels of cerebral functional organization

brain-stem functions (3). The basis of the apallic syndrome must be seen in a structural or functional suppression or disintegration of the cerebrum. An apallic syndrome may follow acute severe brain damage after an initial phase of an acut midbrain and bulbar brain syndrome as a transitory state (3). There may be a complete remission or remission to a defect stage. During the remission stages of the apallic syndrome as well as during the disintegration of brain functions to an apallic syndrome a systemic sequence in the development can be observed as demonstrated in figure 2. On the other hand the apallic syndrome following severe progressive cortical diseases represents an irreversible end-state.

The symptoms of the apallic syndrome are listed in table 3. One of the main symptoms of the apallic syndrome is the reappearance of primitive motor patterns which we divide into 5 groups: 1) the motor patterns of the oral sense; 2) the grasping reflexes; 3) the oro-mental reflexes; 4) the motion and posture actions and 5) the fright responses (7) (Table 4).

TABLE 3: SYMPTOMS OF THE APALLIC SYNDROME

1) COMA VIGILE WITH MAINTAINED SLEEP-WAKENING CYCLES
2) LACK OF EMOTIONAL REACTIONS
3) REAPPEARANCE OF PRIMITIVE MOTOR PATTERNS
4) FIXED BODY AND EYE POSTURE
5) EXTREME DISINHIBITION OF VEGETATIVE FUNCTIONS

TABLE 4: PRIMITIVE MOTOR PATTERNS IN THE APALLIC SYNDROME

1) THE MOTOR PATTERNS OF THE ORAL SENSE
2) THE GRASPING REFLEXES
3) THE ORO-MENTAL REFLEXES
4) THE MOTION AND POSTURE REACTIONS
5) THE FRIGHT RESPONSES

The motor patterns of the oral sense in the apallic syndrome are shown in table 5. The elementary food intake functions which are already developed in the first foetal months remain basically unchanged (12) The nervous substrate for the above mentioned motor patterns is probably located in the brain-stem reticular formation. MONNIER and WILLI (1947) observed in the pontobulbar anencephalus sucking, snout and lip-tap reflexes. They have been observed also in patients in whom the brain-stem and the cerebral hemispheres have been disconnected structurally or functionally by disease. These reflexes consist-of itensity dependent patterned responses of the perioral muscles to noxious stimulti.

The precise pathological physiology of the grasp reflex is unknown, although its association with destructive lesions of the

TABLE 5: MOTOR PATTERNS OF THE ORAL SENSE IN THE APALLIC SYNDROME

ROOTING REFLEX
SUCKING REFLEX
SPONTANEOUS CHEWING AUTOMATISM
SUCKING CHEWING AUTOMATISM
SNOUT REFLEX
LIPTAP REFLEX
MAGNET RESPONSE
BULLDOG REFLEX
ORAL ADJUSTING MECHANISM OF TACTILE AND OPTIC FORM
GNASHING OF TEETH

controlateral frontal lobe is well established. Clinicopathological papers almost always depict the presence of wide spread abnormalities in the frontal lobe, the basal ganglia and even the diencephalic reticular formation.

Two aspects of the grasp reflex, an exteroceptive and a tonic proprioceptive reflex as two separate motor phenomena are discussed (1). The exteroceptive reflex would disappear during the first months of life while the proprioceptive reflex would persist until the end of the first year. Similar phenomena, the so called phasic grasping and tonic grasping reflex are observed in the apallic syndrome obligatory (3).

The so called oro-mental reflexes, mental because of visible contractions of the mental muscles, are found in 80 % of healthy infants. Some authors stress that the palmomental reflex is one of the most frequent reflexes elicited at all ages (2,5). In the apallic syndrome oro-mental responses are always found. The palmomental reflex belongs to the group of the so called "brain-stem reflexes". The Babkin reflex shows a similar pathophysiologic basis and can be seen only in the full stage of the apallic syndrome.

Many of the motion and posture responses represent a mass response, a generalized "turning to" or "turning away". The newborn full term infant adopts a "foetal" position of general flexion of spine and limbs. Flexion is the first motor response pattern in development and initially flexion appears to be primarily an avoiding reaction (9). Receptors for motion and posture reflexes are the vestibular apparatus, the pressuve sensitive receptors of the skin, the proprioceptors of the muscles, tendons and joints, and the eyes. As the primitive local response, e.g., head rithing response, and the primitive general response, e.g. asymmetric tonic neck response, Moro response, wane, other inherent "secondary" responses as rolling, balancing and protective reactions emerge (12). The apallic syndrome is dominated by two forms of body posture: a flexed posture of all extremities or a flexed

posture of arms and hands, and a stretched position of the legs. These postures, of course, are reinforced by a basic-rigid hypertension of the muscles. The asymmetric and symmetric tonic neck reflexes are elicited in nearly every case of an apallic syndrome in a more or less intensive form. These reflexes are important for early physiotherapy in the so called method of tonus-regulating reflex therapy. From the group of the fright responses, the glabella response and the head retraction are seen in the remission stages of the apallic syndrome.

Particular attention is paid to the KLÜVER-BUCY syndrome, in which we have studied primitive motor patterns in patients beeing in the remission phase of an apallic syndrome. KLÜVER and BUCY described changes in the behaviour of adult rhesus monkeys after bilateral removal of a greater portion of the temporal lobes (6). Similar human behaviour and stereotyped motor-patterns have been reported after surgical ablative procedures and in a variety of conditions including arteriosclerosis, epilepsy, hypglycemic cerebral damage, toxoplasmic encephalitis, Alzheimer disease, Pick disease, adrenoleukodystrophy and in the remission of the apallic syndrome. As described by GERSTENBRAND in 1967 symptoms very similar to those observed by KLÜVER and BUCY in their animal models can be observed in humans during the remission phase of an apallic syndrome.

Our own case material consist of 40 patients who came into remission from an apallic syndrome of traumatic etiology. In 22 of them stereotyped oral patterns in the sense of chewing and sucking movements occured with indirect grasping. All reachable objects in the patients visual field are grasped at and raised to the mouth to be biten or chewed or sucked at (Table 6).

In analyzing the evolution of KLÜVER BUCY syndrome during the remission of an apallic syndrome a stepwise development can be detected. It is characterized by the change from compulsive motor patterns in the sense of preformed movement coordinations into oriented and affective actions. In children we could observe a prominent tendency towards indiscrimate embracing or nestling against persons of caressing.

TABLE 6: SYMPTOMS OF KLÜVER BUCY SYNDROME IN HUMANS DURING REMISSION OF AN APALLIC SYNDROME

GRASPING PATTERNS COUPLED WITH ORAL AUTOMATISM
UNABILITY OF OPTIC OR TACTILE RECOGNITION OF OBJECTS
MARKED HYPERSEXUALITY
LACK OF FEAR AND SHAME
MARKED BULIMIA
SEVERE DISTURBANCE OF SHORT TERM MEMORY

SUMMARY

The so called developmental, foetal or primitive reflexes my occur in a variety of brain diseases. These responses are normaly present during the early maturation of the central nervous system and they may reappear when the central nervous system has been altered by age and/or disease. The word "developmental" signifies one aspect of these phenomena, their similarity to normal responses of early life. These reflexes are interpreted as release phenomena, in the sense that they are disinhibited when higher inhibitory and regulatory centres cease to function adequately.

A methodical standardization of the neurologycal examination allows to quantify the responses examined and makes descriptions of motor patterns comparable. This

must be the requirement for the evaluation of primitive motor patterns in the healthy infant and also in the brain damaged adult. Under these circumstances, the primitive motor patterns of the infant are comparable phenomenologically with those in the full stage and in the remission course of an apallic syndrome. But a high variability has to be considered for the functional development of the nervous system. One can speculate that a decrease in variability is one characteristic of the developement of the impaired nervous system leading to stereotypy of responses.

The elements of primitive motor patterns in newborn infants appear in a comparable form in the apallic syndrome and show a biologically purposeful evolution into higher coordinated, oriented actions with connection of grasping and movement patterns of the oral sense. Concerning the primitive motor patterns regulated by the vestibular apparatus as well as the frightening reactions a similar development takes place.

In the model of an apallic syndrome a disintegration of cerebral functions to a mesodiencephalic level is supposed. The apallic syndrome therefore gives further evidence for integration of primitive motor patterns in the brain-stem reticular formation.

The evolution of these primitive motor patterns into the motor patterns of KLÜVER BUCY syndrome suggest that the limbic system represents the following sensorimotor level additionally providing emotional and impulsive reactions.

In addition to the scientific value of such analyses for the Developmental Medicine and Neurobiology we want to point out two practical benefits of them, first the primitive motor patterns as observed in an apallic syndrome show a dynamic evolution and allow prognostic statements and second, the utilization of the tonus regulationg reflexes in the rehabilitation of an apallic syndrome is one of the most important part of the therapy expecially for prevention of secondary defects.

RESUMEN

En distintas enfermedades del cerebro pueden estar presentes los reflejos llamados de desarrollo, fetales o primitivos. Estas respuestas ocurren normalmente durante la maduración precoz del sistema nervioso central y pueden reaparecer cuando el sistema nervioso central sufre alteraciones por la edad o por enfermedad. La designación de "desarrollo" se refiere a un aspecto de estos fenómenos, al hecho de ser similares a respuestas normales de la infancia.

Estos reflejos son interpretados como producto de un fenómeno de liberación, a consecuencia de que son desinhibidos cuando cesan de funcionar en forma adecuada centros superiores de inhibición y regulación.

Una forma metódica de realizar el examen neurológico permite valorar las respuestas observadas y realizar descripciones de modelos motores comparables. Esto es útil para la valoración de modelos motores primitivos en el niño sano así como en el adulto con daño cerebral. Bajo estas circunstancias, los modelos motores primitivos del niño son comparables fenomenológicamente con aquellas del pleno desarrollo y en el curso de la remisión de un síndrome apálhico. Debemos considerar una importante variabilidad en el desarrollo funcional del sistema nervioso. Puede especularse que una variabilidad disminuida es una característica del desarrollo del sistema nervioso afectado que conduce a respuestas esferrotipadas.

Los elementos de modelos motores primitivos en niños recién nacidos se muestran en forma similar en el síndrome apálhico y señalan una evolución biológica dirigida a acciones superiores, coordinadas con orientación, concetando la prehensión y el sentido oral. En lo concerniente a esquemas motores primitivos regulados por el aparato vertibular así como reacciones de tumor, tiene lugar un desarrollo similar.

Se supone que en el modelo de un síndrome apálhico ocurre una desintegración de las funciones encefálicas, a un nivel mesencefálico. El síndrome apálhico de este modo brinda anterior evidencia acerca de la integración de modelos motores primitivos en la formación reticular del tronco cerebral.

La evolución de estos modelos motores primitivos en los modelos motores del síndrome de Kluver-Bucy surgiere que el sistema límbico representa el nivel sensorimotor siguiente que brinda reacciones emocionales e impulsivas.

Agregado al valor científico de tales análisis para la Medicina del Desarrollo y la Neurobiología, deseamos puntualizar dos beneficios prácticos de ellos; primero, los modelos motores primitivos tal como se observan en un síndrome apálhico muestra una evolución dinámica y permite establecer pronósticos y segundo la utilización de reflejos regulante del tono en la rehabilitación de un síndrome apálhico es uno de los elementos más importantes de la terapia especialmente para la prevención de defectos secundarios.

RÉSUMÉ

On observe les réflexes dits foetaux, primitifs ou du développement dans de nombreuses maladies du cerveau. Ils sont normalement présents pendant la maturation du cerveau et peuvent réapparaître lors de la vieillesse ou lors de maladies cérébrales graves. Le concept de "réflexes du développement" réflète la similitude de tels réflexes avec les réflexes physiologiques, normaux de l'enfant. Ces réflexes sont qualifiés de phénomènes de désinhibition, car ils apparaissent lorsque la fonction adéquate de centres régulateurs supérieurs cesse.

Afin de pouvoir juger et comparer les réflexes primitifs moteurs types de l'enfant et ceux du syndrome apallique, il est indispensable de prodéder aux examens neurologiques en suivant rigoureusement le schéma donné. Malgré la grande variation des réflexes primitifs moteurs types chez l'enfant et au syndrome apallique, on peut comparer ces réflexes phénoménologiquement.

Les éléments des réflexes primitifs moteurs chez le nouveau-né existent sous une forme semblable au syndrome apallique; ils témoignent d'une évolution biologique sensée conduisant aux mouvements complexes coordonnés unissant l'action de saisir et le sens oral. On peut faire des observations semblables en ce qui concerne les réflexes primitifs moteurs dirigés par le système vestibulaire. La diminution des fonctions cérébrales au niveau mesodiencéphalique causée par le syndrome apallique permet de prouver que les centres d'intégration des réflexes primitifs se trouvent dans les formations réticulaires du tronc cérébral. La transformation des réflexes primitifs moteurs du syndrome apallique en mouvements caractéristiques du syndrome KUVER BUCY montre que le système limbique constitue le niveau sensoriel-moteur suivant avec apparition de réactions affectives émotionnelles et de réactions impulsives.

ZUSAMMENFASSUNG

Die foetalen oder primitiven Reflexe, auch Entwicklungsreflexe genannt, sowie die motorischen Primitivschablonen und Stereotypien sind in einer Vielzahl von Erkrankungen des Gehirns nachweisbar. Sie sind normalerweise in der Reifungsphase des Gehirns vorhanden und kommen mit zunehmenden Alter oder bei verschiedensten Erkrankungen des Gehirns wieder zum Vorschein. Der Begriff des "Entwicklungsreflexes" spiegelt die Ähnlichkeit solcher Reflexe zu den normalen, physiologischen Reflexen in der Kindheit wieder. Diese Reflexe werden in dem Sinne als Enthemmungsphänomene bezeichnet, als dass sie dann zum Vorschein kommen, wenn höhere inhibitorische und regulatorische und regulatorische Zentren ihre adäquate Funktion beenden.

Eine exakte Standardisierung der neurologischen Untersuchung ist Voraussetzung für die Beurteilung und den Vergleich motorischer Primitivschablonen beim Kind und im apallischen Syndrom. Trotz einer hohen Variabilität der motorischen Primitivschablonen sowohl beim Kind als auch im apallischen Syndrom sind diese Muster phenomenologisch miteinander vergleichbar.

Die beim Neugeborenen bestehenden Bausteine primitiver Motorik sind im apa-

llischen Syndrom in vergleichbarer Form ebenso vorhanden und zeigen eine biologisch sinnvolle Entwicklung bis zu höheren, zielgerichteten Bewegungsabläufen mit Verbindung des Greifens und des Oralsinnes. Ähnliches trifft auch bei den vestibulär gesteuerten motorischen Primitivschablonen ebenso wie für die Gruppe der Schreckreaktionen zu.

Das Modell des apallischen Syndroms mit seinem anzunehmenden Funktionsabfall auf die mesodiencephale Ebene kann als weiterer Beweis für die Integrationszentran motorischer Primitivschablonen in den reticulären Formationen des Hirnstammes dienen. Der Aufbau der motorischen Primitivschablonen zu den Primitivhandlungen des KLÜVER BUCY-Syndroms beweist, dass das Funktionsniveau des limbischen Systems das nächste sensorisch-motorische Funktionsniveau unter Einflechtung emotionell affektiver und Triebreaktionen darstellt.

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