Paediatr Croat 2002; 46 (Supl 1): 121-123

Pregled
Review

FUNDAMENTALS OF DEVELOPMENTAL NEUROLOGY

HEINZ F. R. PRECHTL, CHRISTA EINSPIELER*

Research in developmental neurology has provided a number of important new paradigms on the functional development of the human nervous system. According to the Ontogenetic Adaptation Paradigm, the functional repertoire of the developing neural structure must meet the requirements of the developing individual's organism and its environment. This Paradigm and the evidence of the absence of an "immature" nervous system have introduced two concepts - the age-specific difference and the age-specific vulnerability of the developing nervous system. Therefore, it is necessary to perform a standardised and age-specific neurological examination and age-specific diagnostic procedures, and to apply age-specific therapeutic interventions. The most recent insights have also lead to the development of a new approach in the qualitative assessment of general movements.

Descriptors: DEVELOPMENT; NEUROLOGY; PARADIGM; NERVOUS SYSTEM; ONTOGENETIC

During the last 40 years research in developmental neurology has provided a number of important new paradigms on the functional development of the human nervous system. It is important to understand the historical background on which the previous paradigms were based on and the reasons why they became outdated and are now replaced on empirical grounds.

The Ontogenetic Adaptation Paradigm

One of the most fundamental new insights is the concept of ontogenetic adaptation with its far reaching consequences. This concept acknowledges that during the development of the individual the functional repertoire of the developing neural structure must meet the requirements of the organism and its environment.

Consequences of the ontogenetic adaptation

IMMATURITY DOES NOT EXIST

At different ages we are dealing with different nervous systems. These differences comprise structure as well as the functional repertoire. If these various developmental stages are studied in their own right, it is evident that an "immature" nervous system does not exist. The wrong idea about the immature nervous system stems from an irrelevant reference to later developmental stages. This wrong perspective has previously doomed us to overlook the essential features of each of the rich ontogenetic adaptations. As a consequence, we must realise that each fetus, infant and child has biologically different brains at different ages. Only at adulthood there exists a relatively stable period but this aspect may be only due to our limited knowledge in respect to changes occurring during adult life. So far only the alterations of the brain during ageing have gained close attention.

Age related vulnerability

Another consequence of the age-specific difference of the developing nervous system is the age-specific vulnerability of the nervous tissue.

Many examples can be provided but we shall only mention three, published during the last years. Volpe has indicated that in very young preterm infants the hypoxic-ischaemic lesions of the cortical white matter are due to the less developed oligodendrocytes which are at this stage particularly vulnerable to free oxygen radical attacks but much less so at later development (1). This is a time window for the origin of severe leukomalacia in preterm infants.

Another example are the intraventricular-periventricular haemorrhages in preterm infants. Funato was able to record on ultrasound video the moments of such bleedings (2). They found hypotension as the cause of hypoxia and decreased perfusion, being followed by a normalisation of the blood pressure which is the eliciting factor for the rupture of the vessels with a haemorrhage into the caudate nucleus.

The last example is concerned with prenatal severe bradycardias at term which lead to severe damage of basal ganglia and the thalami whereas the cortical regions remained relatively unimpaired (Okumura et al. 2000), in contrast to later age (3).

* Karl Franzens University of Graz
Department of Physiology
Austria

Adresa za dopisivanje:
Heinz F. R. Prechtl DM, DPhil, FRCOG (hon),
Professor em. of Developmental Neurology,
Harrachgasse 21/5,
A - 8010 Graz
Austria
E-mail: christa.einspieler@kfunigraz.ac.at

Diagnostic procedures need to be age adequate

If the age related properties of the nervous system are fully appreciated, the consequences are age adequate diagnostic procedures. This holds true for the interpretation of neuro-imaging, for reading of EEG or evoked potentials, and not to forget, for the design of neurological examinations. For certain neural functions there exist marked differences between preterm and term age, and hence, it is necessary to have a different design of the neurological examination for these both age groups. In newborn infants born at term almost all neural functions are characterised by a strict dependency on behavioural states. However, preterm infants younger than 36 weeks do not yet have well organised behavioural states. Therefore, for this very young infants a standardisation of the neurological examination in respect to behavioural states is not yet possible. The consequence is a different approach for preterm and term infants.

As any diagnostic procedure must be age related and age adequate, the same holds true for the various therapeutic interventions. There are specific time windows, when specific interventions are optimal to apply.

Properties of neural function during early development

For a long time the neural functions of the young nervous system have been dominated by the reflex and the stimulus-response idea. This is a heritage from classical neurophysiology. While at the end of the 19th century, William Preyer was fully aware of spontaneous movements in the fetus and young infant, reflexology and particularly behaviourism have suppressed these observations (5). The reason for this suppression was the following: Sir Charles Sherrington was interested in the contact between the afferent and the efferent arch in the spinal cord. He hypothetically called this contact the synapse. In order to study the properties of this assumed contact, he had the ingenious idea to eliminate the "nuisance" of spontaneous neural activity by experimental lesions of the nervous system. His reflex studies in dogs, cats and monkeys were performed after decerebration, spinal preparation and anaesthesia. In this way, the input-output relation of stimulation and reflex answer was extremely consistent and no longer interfered by fluctuations in neural activity because of spontaneously generated activity in the nervous system.

Although Sherrington himself was fully aware of the artificial nature of his findings ("the simple reflex is a fiction"), the followers forgot this cautioning statement and made the reflex pattern to the crucial element and building block of neural functions (6). It took a long period to rediscover the previously known important property of neural functions, namely the endogenously generated activity in the central nervous system. Particularly important is the spontaneous activity in the young developing nervous system. It still takes much effort to bring these new findings based on the most advanced techniques of neurobiology through the professional boundaries to clinicians and therapists.

A similarly controversial issue is the concept of tonus or tone. It was introduced into the neurology of the young infant by the eminent adult neurologist Andre Thoma. His excellent book on cerebellar diseases dealt with tonus changes as an important clinical sign. His later his co-operation with the young S. St. Anne Dargassies brought his ideas of tonus testing into infant neurology.

This tradition continued with Claudine Amiel-Tison and the Dubowitzs. Regrettably, the tonus concept is still a mass. Definitions are not standardised and vary greatly, and clinical experience indicates the inconsistent character of tonus in young infants as well as a weak inter-observer agreement. Except for the extremes of tonus deviations such as floppiness or marked hypertonus, the prognostic value of tonus deviations is very low.

A standardised and age specific neurological examination, taking fully into account the age related different properties of the young nervous system, has its important place in the neurological assessment of infants and children. It remains essential to notice that in clinical routine often an eclectic collection of items is employed, which rarely tells the examiner what exactly is wrong in the young nervous system and why this is so. This is probably due to the different conceptional backgrounds of the various examination techniques which are usually not clearly expressed and sometimes not even understood.

In the light of this admitted dilemma in the methodology of early neurological assessment, a new approach based on the most recent insights into the properties of neural functions is an additional help in the assessment of the young nervous system. This new approach is now developed in the qualitative assessment of general movements.

REFERENCES

1. Volpe JJ. Neurological outcome of prematurity. Archives of Neurology 1998; 55: 297-300.
2. Funato M, Tamai H, Takeda Z. Moment of intraventricular haemorrhage-clinical pathogenic events. In: Lou HC, Greisen G, Larsen JF. eds. Brain Lesions in the Newborn. Copenhagen, Munkgaard 1994..
3. Okumura A, Hayakawa T, Kato K, Kuno K, Watanabe K. (2000) Bilateral basal ganglia - thalamic lesions subsequent to prolonged fetal bradycardia. Early Human Development 2000; 58: 111-8.
4. Prechtl HFR. General movements assessment as a method of developmental neurology: new paradigms and their consequences. Developmental Medicine and Child Neurology 2001; 43: 836-42.
5. Preyer W. Die spezielle Physiologie des Embryo. Leipzig, Grieben 1885.
6. Sherrington C. The integrative action of the central nervous system. New York: Scribners (reprinted: 1961, New Haven: Yale University Press) 1906.

Sažetak

OSNOVE RAZVOJNE NEUROLOGIJE

H. F. R. Prechtl, C. Einspieler

Istaživanja na području razvojne neurologije su razotkrila brojne važne i nove paradigme o funkcionalnom razvoju humanog živčanog sistema. U skladu s Ontogenetskom Adaptacijskom Paradigmom, funkcionalni repertoar razvijajuće živčane strukture mora zadovoljiti zahtjeve organizma i okoliša. Ova paradigma, te dokaz o nepostojanju nezrelog živčanog sistema su uvela dva nova koncepta - o dobi ovisnu različitost i o dobi ovisnu osjetljivost razvijajućeg živčanog sistema. Utemeljeno na ovim novim spoznajama, postavlja se nužnost izvođenja standardiziranog i o dobi ovisnog neurološkog pregleda, primjeni o dobi ovisnim dijagnostičkim procedurama, a također i primjeni o dobi ovisnih terapijskih postupaka. Najnovija otkrića su potakla i razvoj nove metode za kvalitativnu procjenu općih pokreta.

Deskriptori: RAZVOJ; NEUROLOGIJA; PARADIGMA; ŽIVČANI SUSTAV; ONTOGENETSKI