MENTAL RETARDATION AND DEVELOPMENTAL DISABILITIES
RESEARCH REVIEWS *11: 34–51 (2005)*

THE AMIEL-TISON NEUROLOGICAL ASSESSMENT AT TERM: CONCEPTUAL AND METHODOLOGICAL CONTINUITY IN THE COURSE OF FOLLOW-UP

Julie Gosselin,[1]* Sheila Gahagan,[2] and Claudine Amiel-Tison[3]

[1]School of Rehabilitation, Faculty of Medicine, University of Montreal, Montreal, Quebec, Canada

[2]Center for Human Growth and Development, Medical School, University of Michigan, Ann Arbor, Michigan

[3]Port-Royal–Baudelocque, University of Paris V, Paris, France

The Amiel-Tison Neurological Assessment at Term (ATNAT) is part of a set of three different instruments based on a neuro-maturative framework. By sharing a same methodology and a similar scoring system, the use of these three assessments prevents any rupture in the course of high risk children follow-up from 32 weeks post-conception to 6 years of age. The ATNAT which takes 5 minutes to administer may be used in clinical setting as well as in research. Clustering of severe to mild neuro-cranial signs in the neonatal period permits identification of children who could benefit from early intervention.
MRDD Research Reviews 2005;11:34–51.

Key Words: neurological assessment; neonatal; neuromaturation; pathophysiological foundations; clusters of signs

A sensitive and specific clinical neurological exam for the high risk neonate should allow the actual assessment of brain status and predict future major as well as minor neurodevelopmental problems. This is even more important in the case of a normal imaging study and an abnormal neurological exam. The updated Amiel-Tison Neurological Assessment at Term (ATNAT) [Amiel-Tison, 2002a] is an extension of the French method of infant neurological evaluation initiated by André Thomas and Saint-Anne-Dargassies [1960]. This assessment is valid for the full-term neonate as well as for the premature infant who has reached 40 weeks corrected age (CA).

Because of the increasing need for better outcome measures, we have devised the ATNAT as part of a series of three instruments [Amiel-Tison, 2001; Amiel-Tison and Gosselin, 2001; Amiel-Tison, 2002a] that have complete continuity in terms of their conceptual framework as well as their assessment methods. Moreover, a single scoring system has been developed beginning with the full-term period and continuing up to school age to allow early detection of neurological impairment, including minor deficits. The continuity of the exam allows the clinician to track the signs of permanent brain damage throughout the first 6 years of childhood. Furthermore, the examiner can elucidate both the neurological signs and their functional impact.

HISTORICAL BACKGROUND

The updated assessment [Amiel-Tison, 2002a] presented here has been developed through continuous study and re-evaluation over more than three decades. Five stages of development are described.

Hands-on Experience at the Source

André-Thomas was fascinated by brainstem activity, which is so conspicuous in the term newborn infant's stage of maturation. He defined passive and active tone and considered tone changes to be valuable clinical signs [André-Thomas and Saint-Anne-Dargassies, 1952]. As a young neonatologist in the early 1960s, one of us (CAT) had the opportunity to train under his protégée, Saint-Anne Dargassies, assessing neonates in Port-Royal–Baudelocque Hospital in Paris. At that time she was accumulating data on the ascending wave of maturation from 28 to 40 weeks' gestation [Saint-Anne Dargassies, 1977].

Understanding the Clinical Significance of Such an Assessment

Meanwhile, a German pediatrician [Peiper, 1963] published a rich description of the neurological performances in the full-term newborn and described the descending wave of maturation of the upper control system in the first years of life. However, it was not until the 1980s, when Sarnat reviewed anatomical and physiological correlates of early neurological development [Sarnat, 1984], that pediatricians became fully aware of the clinical significance of their observations [Amiel-Tison, 1985]. It then became possible to clinically demonstrate the individual development of both upper and lower motor control systems: 1) the lower system, consisting of the brainstem and cerebellum, matures early (beginning at 24 weeks' gesta-

*Correspondence to: Julie Gosselin, School of Rehabilitation, Faculty of Medicine, University of Montreal, C.P. 6128, Succ. Centre-ville, Montréal (Québec), Canada H3C 3J7. E-mail: Julie.Gosselin@umontreal.ca
Received 17 November 2004; Accepted 22 November 2004
Published online in Wiley InterScience (www.interscience.wiley.com).
DOI: 10.1002/mrdd.20049

Table 1. Grading System for the Full-Term Infant

Normal: no signs
Mild: abnormalities of tone and excitability but no central nervous system (CNS) depression and no seizure.
Moderate: abnormalities of tone with signs of CNS depression (poor interaction, hypoactivity, hyporeflexia) and up to two isolated seizures.
Severe: repeated seizures (lasting more than 30 minutes) associated with overt CNS depression from lethargy to coma.

tional age) in an ascending wave and its essential role is to maintain posture against gravity and flexor tone in the limbs; 2) the upper system, consisting of the cerebral hemispheres and basal ganglia, matures later (beginning at 32 weeks' gestational age) and rapidly for the first 2 years in a descending wave and its essential role is to control the lower system, with relaxation of the limbs and control of the antigravity forces, finally allowing erect posture, walking, and fine motor skills.

This distinction became even more relevant after pathological and radiological data had shown that brain damage in the neonate is mainly located in cerebral hemispheres, in the full-term infant with hypoxic ischemic encephalopathy (HIE) or in the premature newborn with periventricular leukomalacia (PVL). Consequently, the best predictors of injury should be found in responses that depend on the upper control system and not in the responses that depend mainly on brainstem activity.

Focusing on the Essential for Clinical Use

These pathophysiological considerations have been the driving force for successive modifications of the clinical assessment at term. More emphasis has been placed on signs that depend on the integrity of the upper structures, such as axial tone and alertness, as well as cranial signs linked to the increase in volume of the cerebral hemispheres. The signs depending on brainstem function, such as primitive reflexes and passive tone in limb flexor muscles have been deemphasized at the neonatal period as they do not provide information about the cerebral hemispheres and basal ganglia.

Developing a Scoring System for Individual Items in the Context of Research

To gain a more precise definition of infant response, a three-point scale has been devised for each item: 0, normal; 1, moderately abnormal; 2, abnormal. This scoring system was initially developed for two clinical studies: 1) on the effects of maternal analgesia on the full-term newborn infant [Amiel-Tison et al., 1982] and 2) on the predictive value of clinical status and imaging data in preterm newborns [Stewart et al., 1988]. The scoring system has been standardized for application beginning with the full-term newborn [Amiel-Tison, 2002a] and continuing up to school age in order to have methodological consistency from birth to 6 years [Amiel-Tison and Gosselin, 2001].

Defining the Clinical Synthesis in the Term Neonate or at 40 Weeks Corrected Age

Since the late 1960s, a graded descriptive system of neurological status has been used routinely in two Parisian referral maternity hospitals to monitor safe obstetrical management in term pregnancies [Amiel-Tison, 1979; Amiel-Tison and Ellison, 1986; Amiel-Tison, 1986; Amiel-Tison et al., 1988]. Infants' neurological status was graded as normal, mildly abnormal, moderately abnormal, or severely abnormal as described in Table 1.

More precision has been subsequently obtained due to the use of the scoring system. Moreover, the consideration of new developments in the understanding of maturation of the visual fix and track [Daum et al., 1980] as well as of sucking [Hack et al., 1985] have added to our ability to identify mild, moderate, or severe neurological abnormalities at term. These additions help to clarify the boundaries between the mild and moderate grades, based on the identification of central nervous system (CNS) depression. This basic assessment can also be applied to the preterm neonate who has reached the full-term period. However, the clinical synthesis has to be more cautious, taking into account the effects of prolonged extrauterine life. Therefore, in the premature, the mild and moderately impaired groups are pooled.

GOAL/OBJECTIVE OF THE TEST

A neurological assessment at 40 weeks corrected age (or at birth for the full-term infant) must be easy to perform, well tolerated by both infants and mothers, and sensitive enough to identify even mild neurological signs and symptoms. If these prerequisites are fulfilled, then the notion of risk (prenatal, perinatal, and postnatal including NICU data) can be replaced by the notion of nonoptimal neurological potential in the infant. This paradigm shift allows follow-up clinics to more appropriately target the infants who require early intervention services. First, many high risk newborn infants do not need systematic neurodevelopmental follow-up even though it is rewarding for pediatricians to demonstrate optimal neurological status in these high risk infants. Second, many "macropremies" considered at low risk (more than 28 weeks' gestational age) should receive close follow-up due to the presence of neurological signs at 40 weeks corrected age [Amiel-Tison et al., 2002]. By redefining the eligibility criteria for systematic follow-up on the basis of an early neurological assessment, more appropriate allocation of resources and earlier intervention can be achieved.

DESCRIPTION OF THE TEST PROCEDURES

The full description of the ATNAT, which includes 35 items clustered into 10 domains, is found in the following texts Amiel-Tison and Grenier [1986]; Amiel-Tison [2001], Amiel-Tison and Gosselin [2001], and Amiel-Tison, [2002b]. The record form (see Assessment Form) provides precise instruction for scoring each item at term. Only a few specific and essential methodological points will be developed in this paper.

Head Growth and Cranial Sutures

The most dramatic increase in brain volume occurs in the second half of fetal life and the first two years after birth. Concomitantly, the skull follows the volumetric increase of the cerebral hemispheres mostly by passive adaptation. The relationship between head and brain growth explains why the classical neurological assessment in infancy universally includes measurement of head circumference (HC). However, this crude information derived from HC measure-

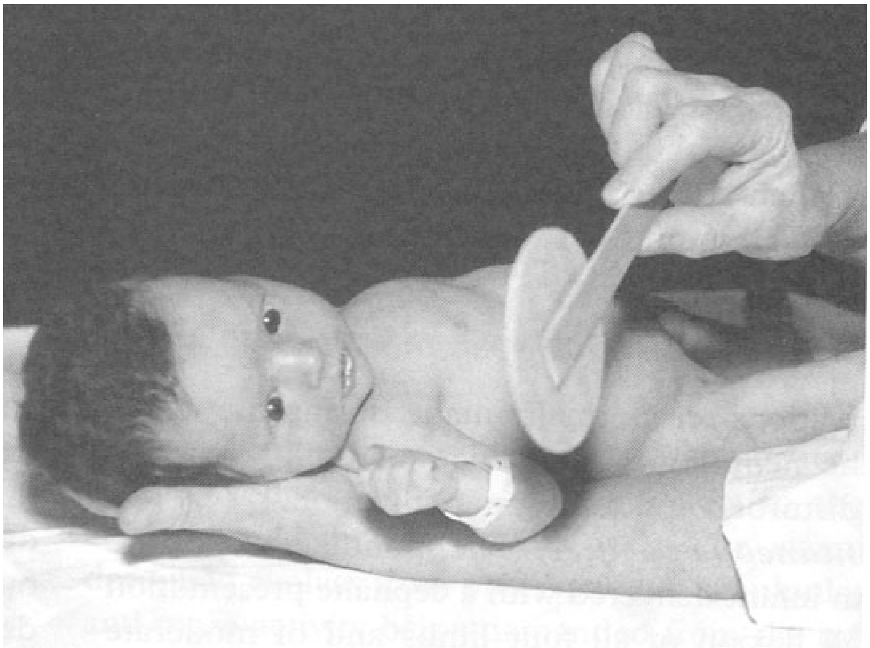

Fig. 1. Fix and track. Testing for fixing and tracking with the "bull's eye." Note the testing position, with head able to rotate on examiner's hand (Adapted from Amiel-Tison C 1999. Correlation between hypoxic-ischemic events during fetal life and outcome. In Arbeille P, Maulik D, Laurini R, editors. Fetal hypoxia. Lancs, UK: Parthenon, p 123–40.)

ment remains insufficient to qualify brain growth. Significant information with respect to the integrity of the underlying cerebral hemispheres can be provided by systematic palpation of the main cranial sutures. In severe cases, every suture is involved, with overlapping being perceived as a ridge. In mild and moderate cases, the squamous suture is particularly informative due to its strategic location at the junction of the cranial vault and the cranial base [Amiel-Tison et al., 2002]. Being located between the parietal and temporal bones, it can be felt by palpation just above the ear. Attention was first drawn to this suture as providing an early sign of hydrocephalus in the newborn when distended [Parmelee, 1961]. Later, the overlapping of this suture was proposed as a marker of moderately decreased brain growth.

Alertness Evaluated on Visual Fix and Track

One of the main interests of testing "fix and track" in a standardized way is to document the infant's quality of alertness. In addition, this test will identify infants with visual impairment, including those with cortical blindness. When the infant is in an isolette, the best way to obtain a visual response is to use the "bull's eye" method [Daum et al., 1980]. The "bull's eye" is a round piece of cardboard printed with glossy black and white concentric circles that is held 20–30 cm from the infant's face (Fig. 1). When the infant has fixed his/her gaze on the "bull's eye," it is then moved twice to the right and twice to the left, four times in a row. When the response is normal, the eyes and then the head follow movements of the target (score = 0). Difficulty in obtaining a response (score = 1) or the repeated absence of any response (score = 2) are considered abnormal. The test is easy to perform and it is easily reproducible by different observers.

Passive Tone in Limbs and Axis

Passive tone refers to the extensibility of muscles when the child is not actively moving and at rest. It is measured by the amplitude of passive movements carried out slowly and gently by the examiner, who must carefully control the force applied without causing discomfort. The infant's head must be kept in the midline during these maneuvers in order to avoid eliciting the asymmetric tonic neck reflex. Extensibility is evaluated by visual estimation of the angle (as for the popliteal angle), by reference to certain anatomical landmarks (as in the "scarf" sign) or by a comparison of the amplitude of incurvations (as in the axis).

As far as passive tone in the limbs is concerned, two maneuvers are enough to verify the quadriflexion (due to the lower control system): the scarf sign is limited such that the elbow does not reach the midline (score = 0) and the popliteal angle is tight, approximately 90° or less (score = 0). These parameters can be complemented by eliciting the two recoil maneuvers: recoil of the upper limbs after extending the forearm passively at the elbow by pulling on the hand and recoil of the lower limbs by pulling on the knee and observing the return to flexion at the hip.

To assess passive tone in the axis of the trunk, the comparison of ventral and dorsal incurvations provides a valid assessment of the upper control exerted over the lower antigravity system. As a great deal of individual variation is observed in the extent of flexion and extension (Fig. 2) at all ages on the one hand, and as it is difficult to describe the value of an incurvation on the other hand, the comparison of both amplitudes has to be considered: flexion normally exceeds extension (score = 0). An abnormal balance is observed when there is no ventral flexion and moderate extension, or excessive extension. Such a result indicates impaired control of the lower system antigravity forces by the upper system (score = 1). Global hypotonia is defined by unlimited flexion and extension (score = 2).

Axial Motor Activity (Active Tone)

Active tone refers to active movements of the infant in reaction to certain situations imposed by the examiner [André-Thomas and Saint-Anne-Dargassies, 1952]. Three responses are elicited by the following items: 1) the active global righting reaction in the upright position; 2) active passage of the head forward during the raise to sit maneuver; and 3) active passage of the head backward when the infant is presented with the back to lying maneuver. These three responses permit analysis of the antigravity forces (lower system) and the control exerted on these antigravity forces by the upper system. We describe the correct technique for each of these three maneuvers here.

To elicit the *righting reaction,* the examiner places the infant in the standing position, with the feet on a horizontal surface while supporting the trunk with one hand. A normal mature response consists of contraction of the extensor muscles of the legs, trunk, and head so that the infant supports his/her own weight (score = 0). Excessive righting with arching (score = 1) as well as absent righting (score = 2) are the two abnormal patterns.

To elicit the active passage of the head forward, the "*raise to sit*" maneuver is performed by the examiner, who holds the infant's shoulders and pulls the neonate from the lying to the sitting position. Active contraction of the neck flexor muscles in an attempt to raise the head to a vertical position is observed in the normal response (score = 0 when easy, in the axis).

To elicit the active passage of the head backward, the reverse maneuver (or "*back to lying*") is done by the examiner who moves the trunk gently backward. A normal reaction consists of an active contraction of the neck extensor muscles in an attempt to raise the head to a vertical position (score = 0 when easy, in the axis).

In a term newborn, active passage forward and backward are easy to obtain, symmetrical and in the axis. When repeated forward–backward movements of the trunk around the vertical position result in a symmetrical response of the flexor and extensor muscles, perfect balance between these two sets of muscles is demonstrated and is a consequence of the stage of maturation of the upper control system. Six to 8 weeks later, this balance will result in beautiful head control. Moderate abnormality may be seen as excessive response in the extensor muscles concomitant with lack of passage forward using the flexor muscles (score = 1). Severe abnormality is noted when weakness or absence of both flexors and extensors responses is observed (score = 2).

It is essential to emphasize that the goal of these combined maneuvers (Fig. 3) is to test the active engagement of agonist and antagonist muscles in the axis in reaction to passive mobilization of the trunk forward and backward. Methodological deviations from the initial description have led to various misinterpretations. The most important and very frequent error in interpretation is that passage of the head is considered as passive. However, flexion forward (early in the raise to sit maneuver, i.e., before verticality is reached) and the extension backward (early in the back to lying maneuver) are both unequivocally active movements. Understanding this allows the examiner to fully appreciate the underlying neurophysiological basis of this activity. One other common methodological error is holding the neonate with the arms extended, which evokes the stretch reflex in the shoulder girdle. This prevents valid interpretation of the active response at the neck level. The trapezius (the main neck extensor muscle) is a

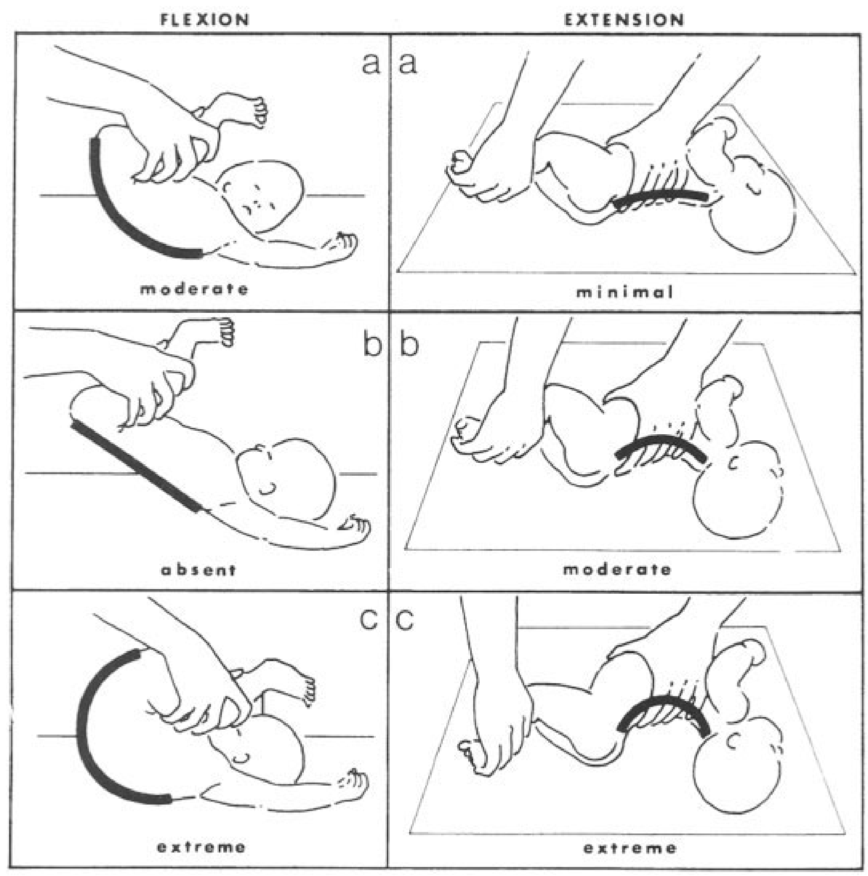

Fig. 2. Passive tone in the body axis. (a) Ventral flexion normally exceeds dorsal extension (score 0). (b) Dorsal extension exceeds ventral flexion (score 1) due to insufficient upper control. (c) Both curvations are extreme due to hypotonia (score 2) (Adapted from Amiel-Tison C 1999. Correlation between hypoxic-ischemic events during fetal life and outcome. In Arbeille P, Maulik D, Laurini R, editors. Fetal hypoxia. Lancs, UK: Parthenon, p 123–40.)

Fig. 3. Neck flexor tone tested by the raise-to-sit manoeuvre. Photographic images obtained sequentially over a 2 second period, showing the active forward lifting of the head. (Adapted from Amiel-Tison C 1999. Correlation between hypoxic-ischemic events during fetal life and outcome. In Arbeille P, Maulik D, Laurini R, editors. Fetal hypoxia. Lancs, UK: Parthenon, p 123–40.)

multiple-joint muscle, and therefore it is essential to hold the infant at the shoulders to isolate the axial activity. Another common methodological mistake is maintaining the neonate in a sitting upright position to observe the drop of the head forward or backward. This allows only testing of passive tone in extensor and flexor muscles as a consequence of the weight of the head. Ignoring the physiological basis of the initial description of active tone exploration has unfortunate consequences on the validity of its interpretation.

DESCRIPTION OF SCORING SYSTEM

As mentioned before, the scoring system for each item involves a nonquantitative three-point scale. The distinction between scores 0 and 2 is usually evident whereas uncertainty may exist with regards to the assignation of a score of 1, the latter indicating an abnormal result of moderate degree. However, precise description of the moderate abnormal performance is included for each item in the record form and should prevent any misinterpretation. Finally, for a few items (mainly referring to sutures' status, asymmetric tonic neck reflex, and automatic walking), scoring may be considered inappropriate or unwise due to the many reasons that could explain the obtained response. Thus, no conclusions shall be made regarding the normal or abnormal nature of these results at this early stage of life. However, this information remains important, as it may be an early sign of a neurological impairment that will emerge in the course of the follow-up. In these cases, the examiner will circle an ≪ X≫ to indicate examination results. The interobserver reliability of this scoring system has been recently tested among 35 infants. The interobserver agreement was estimated with the kappa coefficient, which was considered to be excellent for 16 items, fair to good for 11 items, and poor for 2 items [Deschênes et al., 2004].

TYPICAL DURATION OF TEST/ PROCEDURE

The assessment, which takes about 5 minutes to complete, usually proceeds from observation to manipulation. More activity is demanded from the infant as the examination progresses. No specific order is required. As for most neurological examinations, it should ideally take place after a 2-hour sleep following feeding when the infant is usually quiet but alert, spontaneously awake. The full-term newborn will be tested within the first week of life. One assessment on day 1 or 2 is most often enough. A second assessment may be necessary if alertness does not appear perfect at the first assessment. When a score of 1 or 2 is assigned to some items in the first days of life, repeated assessments will allow the definition of the clinical profile. For the preterm infant, corrected age will be used and the testing will be performed at 40 weeks more or less 14 days [Amiel-Tison, 1999].

CLUSTERS AND FINAL SYNTHESIS

The use of a numerical scoring for each item has been proposed mainly to facilitate the transfer of the results in a database for research purposes. However, no attempt should be made to compute a score by simply adding the results obtained for each item. This reductionist approach could lead to the loss of relevant information. The final synthesis has to be based on the clustering of signs and symptoms. An *optimal status* is defined by the absence of neurological signs. The *nonoptimal status* can be graded into three categories for full-term infants and two categories for preterm infants for whom it may be more difficult to distinguish between mild and moderate degrees of impairment due mainly to extraneurological problems that may interfere with the interpretation of the performances in the very-low-birth-weight infants. The excellent interobserver reliability for the final synthesis was confirmed (kappa coefficient = 0.76) [Deschênes et al., 2004].

TRAINING REQUIRED

Training pediatricians and other professionals to perform the assessment is much easier today because of our greater understanding of the underlying neurophysiology. We therefore begin by explaining the pathophysiological correlates for each maneuver. The transmission of manual skills has been facilitated by pictures and drawings accompanying precise descriptions [Amiel-Tison and Grenier, 1986; Amiel-Tison, 2001] and videotape [Amiel-Tison and Lafaurie-Levêque, 2001]. A master–apprentice situation is the most efficient method of training, with a few infants being tested at one time. In our experience, such training is very satisfactory for general practitioners or midwives who have no experience in neurological assessment. However, pediatricians, who have preconceived ideas about how to do the exam and have not considered the developmental neurophysiology, may need more time to understand the developmental nature and the meaning of the exam.

SIGNIFICANCE OF TEST RESULTS

Previous studies have shown the good validity of the original version of the ATNAT in 28 full-term infants after presumed hypoxic–ischemic brain injury [Amess et al., 1999] and in 111 very preterm infants [Stewart et al., 1988] to predict neurodevelopmental outcome. These results suggest that a normal exam soon after a neurological injury in a term infant is reassuring. An abnormal exam that persists, as time passes after the injury, becomes more predictive of an unfavorable outcome [Amess et al., 1999]. In the preterm infants born before 33 weeks' gestational age, none of the infants who had a normal brain ultrasound and a normal ATNAT had a major developmental disorder and only 2% had a minor developmental disorder, including strabismus, mild sensorineural hearing loss, or mild neurological signs without functional impact [Stewart et al., 1988].

Two recent studies have documented the predictive validity of the updated ATNAT in relation to developmental performances in childhood. Both studies involved neonatal neurological evaluation with the ATNAT at term age; neurological status was scored as optimal status (OS) and nonoptimal status (NOS). Due to the low sample size, the latter category included all infants showing moderate or severe neurological signs. In the first study, the Bayley Scales of Infant Development-II was used to assess the developmental performances at around 1 year of age (mean corrected age = 11 months 12 days) in 25 children (13 OS and 12 NOS) who stayed at least 24 hours in the neonatal intensive care unit [Deschênes et al., 2004, personal communication]. Significant differences were found for mental developmental index (OS: 91.2 ± 13.6 versus NOS: 80.8 ± 15.9 $t = 1.717$, $P = 0.01$) and psychomotor developmental index (OS: 94.5 ± 8.0 versus NOS: 81.6 ± 15.4 $t = 2.639$, $P = 0.02$). In the second study, 34 children born following uteroplacental insufficiency were assessed with the Griffiths Mental Scales during the preschool period at a mean age of 3 years 8 months ± 1 year 2 months [unpublished data]. As shown in Table 2, developmental quotients were lower in the NOS group for all six domains assessed with the Griffiths Scales. The differences were significant for the global score as well as for the motor and the social/personal subscales. These preliminary results suggest that the neonatal neurological status as measured by ATNAT is a good predictor of subsequent developmental performance and should be an inclusion criterion for long-term neurodevelopmental surveillance. This hypothesis is currently being tested in an on-going longitudinal study.

Table 2. Developmental Performances Measured with the Griffiths Mental Scales at Preschool Age According to Neonatal Neurological Status

Domain	Optimal Status (OS) $N = 24$	Nonoptimal Status (NOS) $N = 11$	T	P
Locomotor	94.7 ± 9.9	87.1 ± 12.2	1.957	0.050
Coordination	98.8 ± 15.6	93.0 ± 16.5	1.002	0.324
Performance	104.7 ± 15.5	95.6 ± 15.2	1.611	0.117
Language	93.9 ± 13.2	87.0 ± 14.9	1.383	0.176
Reasoning	89.3 ± 7.2	83.8 ± 9.9	1.595	0.124
Social/personal	99.0 ± 7.9	90.2 ± 9.3	2.913	0.006
Global	97.0 ± 8.2	89.6 ± 10.3	2.284	0.029

CAUTIONS AND LIMITATIONS

For the very preterm or very sick newborn, the observation of spontaneous movements [Einspieler and Prechtl, 2005] and behaviors [Salisbury et al., 2005] remains the only access to brain functioning. However, around term, most neonates are able to tolerate the minimal handling involved in the current assessment. Nevertheless, some limitations that are not specific to this method must be understood. Four situations described below may lead to various misinterpretations.

Deformations

Deformation *in utero* often occurs at the end of pregnancy, due to restriction of space. The most common neonatal deformations are torticollis and plagiocephaly, especially in multiple pregnancy. Deformations may also be acquired postnatally in the NICU when abnormal postures have been tolerated for a long time in very sick premies. Whatever the cause of the deformation, it may alter the responses, particularly in axial tone. For instance, when the head does not pass forward in the raise to sit maneuver, it is not possible to differentiate insufficient upper control exerted on the antigravity system from shortening of the trapezius muscle due to a prolonged abnormal posture. It is only after intense physical therapy and posturing that a peripheral impairment can he ruled out. Neurological assessment is meaningful if and only if the body is not deformed. This is one reason why correcting prenatal deformations and maintaining physiological postures in the NICU and at home, after discharge, is so essential.

Persisting Extraneurological Pathology

At 40 weeks CA, persisting extraneurological conditions may create difficulties of interpretation or prevent completion of the assessment. Cardiac, respiratory, or digestive problems are examples of conditions that may confound the exam.

Poor Adaptation to Handling during Assessment

Various changes in neonatal stability may also obstruct the assessment. Changes may be transient and followed by completion of the assessment or severe with destabilization of the infant. The latter is in and of itself a potential marker of poor brain status.

Continuous Feeding

Continuous feeding may alter the state organization. For instance, visual fix and track may be more difficult to obtain because the state of alertness itself is more difficult to obtain when the infant is continuously fed.

STRENGTHS AND BENEFITS

The benefits from such an exam are numerous not only for the medical team and the researchers but also for the parents.

Parents

This assessment provides useful information to the parents about how their neonate responds. In the absence of any noxious stimuli, the spectacular demonstration of visual pursuit, for instance, makes the assessment pleasant to watch. Moreover, when a neonate is properly held and handled during the assessment, and passive shaking of the head is avoided, his or her ability to communicate is enhanced. This aptitude for interaction has been present since birth but may be discovered, for the first time, on this occasion by inexperienced parents. Observing such an interaction in person may positively influence mother and infant bonding and mutual pleasure [Widmayer and Field, 1981]. Moreover, when parents have been worried about risk factors during pregnancy or birth, observing their child's optimal re-

Fig. 4. Neonatal signs indicating a prenatal insult. High-arched palate. Cortical thumb in a clenched fist. Cranial ridges on every suture. (Adapted from Amiel-Tison C 2001. Clinical assessment of the infant nervous system. In Levene ML, Chervenak FA, Whittle M editors. Fetal and neonatal neurology and neurosurgery, 3rd ed. London: Churchill Livingstone, p 99–120.)

sponses helps to relieve their anxiety better than any verbal explanations.

Obstetricians

This assessment provides early feedback on neonatal neurological morbidity to the obstetric team. It can also be helpful in cases of litigation. Birth asphyxia is often poorly defined: the neurological signs present early in life are considered necessary to identify neonatal encephalopathy and to establish a possible causative link between birth circumstances and outcome. *A contrario*, an optimal neurological assessment at birth eliminates asphyxia as the etiology of later problems [Hankins and Speer, 2003]. If the assessment has not been completed or has not been properly documented, this lack of information can be very damaging to the obstetrician in case of later litigation.

Pediatricians

When self confidence is acquired by the pediatrician, such an assessment, repeated and interpreted according to the medical context of gestation and birth problems, provides a better understanding of different situations illustrated in the following two examples:

Non specificity and lability of early neurological signs are well recognized in the early stages of extrauterine adaptation. However, distinguishing between transient effects of cardiorespiratory and metabolic problems of the newborn from the specific expression of brain damage remains challenging. Repeated assessments provide the most valid procedure to resolve the difficulty posed by the fluctuations of clinical signs in the acute phase of adaptation, which may be due to factors such as poor alertness, poor reactivity, and moderate hypotonia. This is why a nonoptimal status cannot be defined and graded before the end of the first week [Amiel-Tison et al., 2004].

Clinical profiles based on repeated assessments provide a diagnostic clue when neurological signs and symptoms are found at the first assessment. Clinical assessments repeated daily or every other day can distinguish two different types of profiles. *An evolving profile* is revealed by signs of CNS depression increasing within the first 3 days and then decreasing progressively with marked improvement of alertness, motor activity, and sucking. This profile is typical of recent insult, most often intrapartum. *A stable profile* is revealed by the absence of any change in repeated assessment in the first week of life. This latter profile is typical of a prenatal insult that occurred several weeks earlier *in utero*. In such cases, the presence of three signs in the first days of life represent a precious clue to fetal brain damage (Fig. 4): 1) high-arched palate (due to insufficient molding forces of a hypoactive tongue); 2) nonreducible adduction of the thumb in a clenched fist (due to absence of spontaneous motor activity); and 3) cranial ridges over each suture or restricted to the squamous suture, due to severe or moderate impairment of hemispheric growth [Amiel-Tison, 1999].

Researchers

The recent modifications made on the ATNAT greatly facilitate data collection for research purposes. Its excellent interobserver reliability supports its use in multicentric epidemiological studies to enrich the definition of neonatal morbidity in terms of severity of the neurological signs as well as profiles of evolution. Moreover, redefinition of the selection criteria for clinical trials on early neurodevelopmental intervention based on the neurological assessment should allow a more valid measure of the treatment efficacy according to the initial neurological status.

CONCLUSION

Rigorous and repeated observations of the normal early neurological development have been the basis to define the initial content of the ATNAT (see Assessment Form, p 42–51). Subsequent neurophysiopathological studies have brought support to its content validity as well as its construct validity. Furthermore, recent follow-up studies also support its predictive validity. In this article, we reviewed the development of the ATNAT. We emphasized the underlying pathophysiological meaning of each observation or maneuver that has to be understood by beginners to rapidly acquire proper clinical abilities and judgment. That is especially true for the maneuvers related to active tone, which have often been grossly misunderstood even by experts. The ATNAT is a simple, brief assessment administered at full term or its equivalent in the preterm infant. This is a critical moment when the medical team must synthesize the prenatal, perinatal, and neonatal intensive care associated risks and anticipate the long-term outcome of the infant. As part of a longitudinal assessment tool that can be used until age 6, the ATNAT allows the clinician and the family to begin high risk follow-up with a more accurate assessment of the child's future needs.

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AMIEL-TISON NEUROLOGICAL ASSESSMENT AT TERM

Claudine Amiel-Tison, Julie Gosselin, Françoise Lebrun and Sheila Gahagan

Name	______________________	Birth date	M ☐ D ☐ Y ☐
Mother's name	______________________	Gestational age (wk)	☐
Chart number	______________________	Sex	M ☐ F ☐

Assessments

Number	**1**	**2**	**3**	**4**
Date of assessment				
Day of life				
Corrected age (wk)				
Weight (g)				
Height (cm)				
Head circumference (cm)				

INSTRUCTIONS

For whom?
Term neonates within the first days of life and preterm neonates closest to the term period (between 37 and 42 weeks corrected).

How to code?
A numerical system is proposed to code the observations . Level of severity in abnormal responses is defined.
0 indicates a typical result, within normal range
1 indicates a moderately abnormal result
2 indicates a definitely abnormal result
X indicates examination results when scoring is considered inappropriate because the normal or abnormal character of the observation cannot be defined with certainty.

This coding system is not quantitative. Thus, any computation of quotient or total score is inappropriate.

Pregnancy and birth

Single .... ☐
Multiple : twin ☐
higher.......... ☐

Vaginal delivery : cephalic ☐
breech.......... ☐
Cesarian section planned or repeated ☐
emergency cs ☐

Apgar 1' ☐ 5' ☐

Growth parameters at birth

Weight	☐	g	☐	centiles
Height	☐	cm	☐	centiles
Head circumf (HC)	☐	cm	☐	centiles
Mid arm circumf.	☐	cm	☐	centiles

Postural deformities (acquired in utero or postnatally)

Skull .... ☐
Neck.......... ☐
Body axis.......... ☐
Upper limbs .... ☐
Lower limbs .... ☐

Describe:

Mechanical consequences of birth process

Caput succedaneum.......... ☐
Cephalohematoma .... ☐
Severe cranial molding .... ☐
Facial ecchymosis .... ☐
Bruising from forceps (if extensive, asymmetrical or abnormally located) ☐
Facial paralysis.......... ☐
Brachial plexus paralysis .... ☐
Hematoma of SCM .... ☐
Fracture of the clavicle.......... ☐
Other.......... ☐

Socioeconomic data

Maternal age ☐

Maternal education ☐

Presence of the father at home yes ☐ no ☐

Parental growth parameters

	Mother	Father
HC	☐	☐
Height	☐	☐

CRANIAL ASSESSMENT

		1	2	3	4
Head circumference	± 2SD	0	0	0	0
	> 2SD	X	X	X	X
	< 2SD	X	X	X	X
Anterior fontanellel	Normal	0	0	0	0
	Tense	X	X	X	X
Squamous sutures	Edge-to-edge	0	0	0	0
	Separated	X	X	X	X
	Overlapping	X	X	X	X
Other sutures	Edge-to-edge	0	0	0	0
	Separated	X	X	X	X
	Overlapping	X	X	X	X

NEUROSENSORY FUNCTION AND SPONTANEOUS MOTOR ACTIVITY DURING THE ASSESSMENT

		1	2	3	4
Fix and track	Easy to obtain 4 times	0	0	0	0
	Difficult to obtain	1	1	1	1
	No response	2	2	2	2
Ocular signs	Absent	0	0	0	0
	Present, describe ________	X	X	X	X
Response to voice	Easy to obtain	0	0	0	0
	Difficult to obtain	1	1	1	1
	No response	2	2	2	2
Social interaction	Easy and spontaneous	0	0	0	0
	Poor and limited	1	1	1	1
	No interaction	2	2	2	2
Crying	Normal pitch, easy to calm	0	0	0	0
	Monotoneous, abnormal pitch	1	1	1	1
	Absent	2	2	2	2
Excitability	Consolable, normal sleep	0	0	0	0
	Excessive crying, insufficient sleep	1	1	1	1
	Tremors and/or clonic movements	1	1	1	1
Convulsions	Absent	0	0	0	0
	Present (1 or 2)	2	2	2	2
	Repeated for more than 30 min.	2	2	2	2
	Describe variety				
Spontaneous motor activity	Varied, harmonious	0	0	0	0
	Insufficient, stereotyped	1	1	1	1
	Absent or barely present	2	2	2	2
	Asymmetrical (pathological side)	R | L	R | L	R | L	R | L
Spontaneous thumb abduction	Active thumb	0	0	0	0
	Inactive thumb	2	2	2	2
	Fixed thumb in adduction	2	2	2	2
	Asymmetrical (pathological side)	R | L	R | L	R | L	R | L

PASSIVE MUSCLE TONE

			1 R	1 L	2 R	2 L	3 R	3 L	4 R	4 L
UPPER LIMBS	Recoil	Quick, reproducible	0	0	0	0	0	0	0	0
		Slow, not reproducible	1	1	1	1	1	1	1	1
		Absent	2	2	2	2	2	2	2	2
	Scarf	Elbow does not reach midline	0	0	0	0	0	0	0	0
		Elbow slightly passes midline	1	1	1	1	1	1	1	1
		No resistance	2	2	2	2	2	2	2	2
LOWER LIMBS	Recoil *	Quick, reproducible	0	0	0	0	0	0	0	0
		Slow, not reproducible	1	1	1	1	1	1	1	1
		Absent	2	2	2	2	2	2	2	2
		Value of the angle								
	Popliteal angle*	70 - 90°	0	0	0	0	0	0	0	0
		100 - 120°	1	1	1	1	1	1	1	1
		130° or more	2	2	2	2	2	2	2	2

* No coding in cases of breech delivery

			1	2	3	4
RIGHT-LEFT COMPARISONS	Asymmetry	Absent or not categorized	0	0	0	0
		Right side more relaxed	X	X	X	X
		Left side more relaxed	X	X	X	X
BODY AXIS	Ventral incurvation (flexion)	Moderate, easy to obtain	0	0	0	0
		Absent or minimal	1	1	1	1
		Unlimited	2	2	2	2
	Dorsal incurvation (extension)	Absent to moderate	0	0	0	0
		Opisthotonos (excessive)	2	2	2	2
	Comparison of curvatures	Flexion ≥ extension	0	0	0	0
		Flexion < extension	1	1	1	1
		Flexion & extension unlimited	2	2	2	2

AXIAL MOTOR ACTIVITY (active tone)

		1	2	3	4
Righting reaction (Lower limbs + trunk)	Present, complete or not	0	0	0	0
	Excessive with arching	1	1	1	1
	Absent	2	2	2	2
Raise to sit (neck flexor muscles →head forward)	Easy, in the axis	0	0	0	0
	Muscle activity but no passage	1	1	1	1
	No response	2	2	2	2
Reverse maneuver (neck extensor muscles →head backward)	Easy, in the axis	0	0	0	0
	Brisk, excessive response	1	1	1	1
	No response	2	2	2	2

PRIMITIVE REFLEXES

		1	2	3	4
Non nutritive sucking	Rythmic movements, efficient	0	0	0	0
	Few movements, inefficient	1	1	1	1
	No movements	2	2	2	2
Palmar grasp	Strong finger flexion	0	0	0	0
	Weak, short duration	1	1	1	1
	Absent	2	2	2	2
	Asymmetrical (pathological side)	R | L	R | L	R | L	R | L
Automatic walking	A few steps, easy to obtain	0	0	0	0
	Difficult to obtain or absent	X	X	X	X
	(no concern if isolated finding)				
Moro reflex**	Brisk, with opening of the hands	0	0	0	0
	Incomplete	1	1	1	1
	Absent	2	2	2	2
	Asymmetrical (pathological side)	R | L	R | L	R | L	R | L
Asymmetric tonic neck reflex (ATNR)	Absent	X	X	X	X
	Present	X	X	X	X

**** to assess only when other primitive reflexes are asymmetrical or absent**

PALATE AND TONGUE

High arched palate	Absent	0	0	0	0
	Present	2	2	2	2
Fasciculations of tongue (peripheral, at rest)	Absent	0	0	0	0
	Present	2	2	2	2

ADAPTEDNESS TO MANIPULATIONS DURING ASSESSMENT

Stability	Excellent	0	0	0	0
	Transient changes	1	1	1	1
	Severe destabilisation	2	2	2	2

FEEDING AUTONOMY

Term newborn	Immediate, easy	0	0	0	0
	Incomplete	1	1	1	1
	Absent until day 7	2	2	2	2
Preterm infant close to term	Present, easy	0	0	0	0
	Incomplete	1	1	1	1
	Absent	2	2	2	2

MEDICAL STATUS AT THE TIME OF ASSESSMENT

		1	2	3	4
Term neonate (within the first week)	Assisted ventilation	X	X	X	X
	Anticonvulsant drugs	X	X	X	X
	Phototherapy	X	X	X	X
	Other	X	X	X	X
Preterm infant at the time of examination					
Persisting extraneurological pathology	Cardiac problems	X	X	X	X
	Respiratory problems	X	X	X	X
	Digestive problems	X	X	X	X
	Retinopathy	X	X	X	X
	Other (describe)	X	X	X	X

UNFAVORABLE CIRCUMSTANCES AT THE TIME OF EXAMINATION

Condition(s)	Has just been fed	X	X	X	X
	Too hungry	X	X	X	X
	Noisy environment	X	X	X	X
	Other (describe)________________	X	X	X	X

COMPLEMENTARY INVESTIGATIONS

	Date	Results
CRANIAL ULTRASOUND		
CT-SCAN OR MRI		
CSF		
Optic fundi		
EEG		
BAER		
Other		

HOW TO ACHIEVE A SYNTHESIS OF THE DATA

For the term newborn infant (page 49):

In the absence of any abnormality at the first assessment (day 1 or 2), synthesis relies on this single assessment.

In the presence of abnormalities at the first assessment, synthesis relies on repeated assessments within the first week of life.

For the preterm infant around 40 weeks corrected (page 50):

Synthesis is based on a single assessment performed as close as possible to 40 weeks.

SYNTHESIS FOR TERM NEWBORN INFANTS

ABSENCE OF ANY NEUROLOGICAL SIGN	☐

PRESENCE OF NEUROLOGICAL SIGNS, VARIABLE DEGREES	☐			
Minor degree, without CNS depression				
Hyperexcitability	☐			
Various abnormalities of passive tone	☐			
Normalized by day 3	**Yes**	☐	**No**	☐
Normalized by day 7	**Yes**	☐	**No**	☐
Moderate degree, with CNS depression				
Lethargy poor fix and track	☐			
Hypoactivity	☐			
Passive hypotonia in limbs	☐			
Poor activity in neck flexors	☐			
Primary reflexes poor or absent	☐			
Seizures (1 or 2)	☐			
Normalizedby day 7	**Yes**	☐	**No**	☐
Severe degree, with deep CNS depression and repeated seizures for more than 30 minutes				
Duration of status epilepticus	________ hours			
Duration of assistive ventilation	________ days			
Duration of absence of feeding autonomy	________ days			

EVOLVING PATTERN BASED ON REPEATED EXAMINATIONS	
Dynamic (tendency to aggravation followed by improvement)	☐
Static (few or no changes)	☐

SIGNS IN FAVOR OF A PRENATAL INSULT (present at birth)	
Cortical thumb	☐
High-arched palate	☐
Overlapping sutures (with or without microcephaly)	☐

UNCONCLUSIVE RESULTS	
Due to unfavorable circumstances for examination	☐

SYNTHESIS FOR PRETERM INFANTS AROUND 40 WEEKS CORRECTED

ABSENCE OF ANY NEUROLOGICAL SIGN	☐

PRESENCE OF NEUROLOGICAL SIGNS, VARIABLE DEGREE	☐
Minor to moderate degree Score 1 obtained on some or most of the items (imperfect responses concerning alertness, spontaneous activity, active tone, sucking)	☐
Severe degree Score 2 obtained on some or most of the items (no fix & track, no spontaneous activity, no activity in neck flexors excessive dorsal incurvation, no sucking)	☐

PERSISTING EXTRANEUROLOGICAL PATHOLOGIES	
Cardiac problems	☐
Respiratory problems	☐
Digestive problems	☐
Retinopathy	☐
Muscle shortening or deformations	☐
Other (describe)	☐

UNCONCLUSIVE RESULTS	
Due to unfavourable circumstances for examination	☐

PROVISIONAL CONCLUSION ON THE PROBABLE CAUSE OF NEUROLOGICAL IMPAIRMENT

- Brain malformation ☐
- Genetic syndrome ☐
- Hypoxic-ischemic encephalopathy ☐
  - prenatal ☐
  - intrapartum ☐
  - postnatal ☐
- White matter damage ☐
- Infarction of an arterial territory ☐
- Infectious process ☐
- Other (describe) ☐

RECOMMENDED FOLLOW-UP